Anterior Cruciate Ligament Reconstruction with Quadrupled Hamstring Tendon Graft – A Prospective Follow up study

&

A Study of proprioception in the Anterior Cruciate Ligament Deficient Knee

A dissertation submitted to the Tamil Nadu Dr. M.G.R. Medical University in partial fulfillment of the requirement for the award of M.S. Branch II (Orthopaedic surgery) degree March 2007 – 2009.

CERTIFICATE

This is to certify that this dissertation ***"Anterior Cruciate Ligament Reconstruction with Quadrupled Hamstring Tendon Graft – A Prospective Follow up study & A Study of proprioception in the ACL deficient knee"*** is an original work of research done by Dr. S. V. Justin Arockia Raj, towards partial fulfillment of the requirements for the award of MASTER OF SURGERY (Branch II, Orthopaedic surgery) Degree.

Signature of the Guide

Dr. Ravi Jacob Korula,
D. orth.,M.S.Orth., FACS Orth. Surg.,
Professor & Head,
Department of Orthopaedics unit – II.

Signature of the H.O.D

Dr. Vrisha Madhuri
D.orth., M.S. Orth., M.Ch(L'pool)
Professor & Head,
Department of Orthopaedics.

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ACKNOWLEDGEMENTS

First and foremost, I thank the Almighty God and Mother Mary for giving me the strength and capability to learn the art of Orthopaedic science and surgery, to perform my work and fulfill my duties.

I take this opportunity to express my heartfelt gratitude to my guide, Prof. Ravi Jacob Korula, Head of Orthopaedic unit II, for his guidance, love, support and encouragement throughout the past years.

My sincere thanks to Dr. Pradeep Poonnoose without whose help this study would not have been possible at all. Thanks for all the help, prompt guidance at any time of the day, for teaching me a lot, for being supportive throughout ,for being the mastermind behind this work.

I thank Dr.Suresh Devasahayam, Ms. Syrpai Lyne Wankhar for the help on the sophisticated electronics to make the study valid. Thanks to Mr. Prabhav and Mr. Rajdeep for helping me out with the equipment whenever we needed help.

I thank all my co-investigators, Prof. Vernon N Lee, Prof. Alfred Job Daniel, and Dr. Anil Oommen, for the timely advice and support.

I thank Prof. G.D. Sundararaj, Prof. Samuel Chittranjan, Prof. Vrisha Madhuri for the support, encouragement and guidance towards the thesis.

I am also grateful to other faculty members of the Department and my colleagues who helped me to perform this study. A note of appreciation for my friends, Dr. Ige Abraham, Dr. Rajiv Karthik and Dr. Kishore Kumar Pichamuthu for their support and help.

I would like to acknowledge the financial help by the FLUID research grant from Christian Medical College, and the statistical help from Mr. Prasanna, and Ms. Nithya.

I thank Mr. Senthil Vel kumar and Dr. Deepak Samson , for all the help towards the success of this study.

And last, but not the least, I would like to thank, my late father, Mr. S. Vincent, my mother, my wife Dr. Maggie , my son and all the other family members for all the support, patience, for giving me this opportunity and for being a pillar of strength whenever I needed them. Their blessings and teachings are forever cherished.

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INTRODUCTION

1.1 Quadrupled hamstring tendon graft

The popularity of the use of hamstring tendons in anterior cruciate ligament reconstruction has increased in recent years. Compared with the bone-patellar tendon-bone graft however, in terms of stability and clinical results, the initial results were inferior[1,2,3]. Recent investigations have found superior material properties of the equally tensioned quadrupled-looped semitendinosus and gracilis tendons graft[4] compared with the bone-patellar tendon-bone graft. Furthermore, the mechanical properties of hamstring tendons seem to be preserved with increasing age, in contrast to the bone-patellar tendon-bone graft, which seems to weaken with age[5].

The initially inferior clinical results with the hamstring graft could also be explained by inadequate graft fixation. Steiner et al[6] were the first to demonstrate that a direct and strong fixation of the hamstring graft to bone was the key to success. New fixation devices have been introduced to improve fixation of the hamstring graft, and the clinical results have improved in terms of patient satisfaction, joint stability, and sports activity recovery[7,8].

In the bone-patellar tendon-bone group, there is a high incidence of postoperative kneeling discomfort and an increased area of decreased skin sensitivity following

the surgery. To overcome these problems, the hamstrings were used as a graft for reconstruction. Several studies have shown almost equal functional and clinical results using the two grafts*. In this study, we plan to audit the results of our patients who have had hamstring tendon graft for ACL deficient knees.*

1.2 Proprioception:

Anatomical reconstruction of the torn ACL using different types of grafts is meant to restore normal functions of the knee. Proprioceptive functions of the knee are very important for the integrity and stability of the joint. Many clinical studies have shown that the knee joints of patients with ACL tear have a decline in proprioceptive functions of the injured joint. However, improvement of proprioceptive functions of the knee after ACL reconstruction is a subject of considerable debate. While MacDonald et al[9], Co et al and Jerosch and Prymka[10]did not show improvement of proprioception in their patients with ACL reconstruction, other investigators found an improvement after reconstruction. Contradictory results were attributed to the method, and the test used to quantify the overall proprioceptive ability of the examined knee. In general, the tests used evaluate either joint position sense, or kinaesthesia (joint motion sense).

Proprioception is the sum of kinaesthesia and joint position sense. *Kinaesthesia* is defined as the awareness of joint movement and is dynamic. *Joint position*

sense (JPS) is restricted to the awareness of the position of a joint in space and is a static phenomenon. Proprioception can also be defined as the cumulative neural input to the central nervous system from specialized nerve endings called mechanoreceptors. These are located in the joint capsules, ligaments, muscles, tendons, and skin. Some of these receptors (for example, Pacinian corpuscles) are stimulated in the initial and terminal stages of the range of movement of joints as well as during rapid changes in velocity and direction (kinaesthesia). On the other hand the Ruffini end organ-like receptors and Golgi tendon organ-like receptors have been associated with a response to the relative position of muscles and joints (joint position sense). However, in the literature the terms kinaesthesia, joint position sense and proprioception are often used synonymously.

Modulation of muscle contraction involves a complex relation between the agonist, the antagonist, and the contra lateral limb muscles as well. We believe a similar relationship exists between the proprioception of the affected knee, and the contra lateral 'normal limb'. If such a relation ship exists, this could have large implications, as this could suggest that proprioception of the operated knee could be enhanced by training the contra lateral 'normal' knee joint.

Hence in the second part of the study, we aim to assess the proprioception of the ACL deficient knee, and the contra lateral 'normal knee', and compare them with the proprioception in knees of normal healthy volunteers – both in terms of on kinesiology and joint position sense.

AIMS & OBJECTIVES:

1. To audit the clinical outcome in Anterior Cruciate Ligament(ACL) deficient knees reconstructed using Quadrupled Hamstring Graft.

2. To audit the functional outcome in Anterior Cruciate Ligament (ACL) deficient knees reconstructed using Quadrupled Hamstring Graft.

3. To assess the loss of proprioception in the ACL deficient knees as compared to the normal ‘control’ knees.

4. To compare the proprioception of the contralateral ‘normal’ knee, with that of the normal knee joint of healthy volunteers.

5. To assess the loss of proprioception in the ACL deficient knee as compared to the contralateral ‘normal’ knee

Review Of Literature

3.1 ACL anatomy:

The Anterior Cruciate Ligament is extra-synovial and it consists of two bundles, antero-medial and postero-lateral bundle. It originates from the posterior part of the medial surface of the lateral femoral condyle and inserts on the tibial plateau, in a depressed area antero-lateral to the anterior tibial spine. The ligament is 31-35mm in length and 31.3mm^2 in cross section. This ligament prevents the anterior translation of the tibia on the femur.

The posterior articular nerve innervates the ligament. Majority of the nerve fibers are associated with the endoligamentous vasculature and appear to have a vasomotor function. Few fibers have been observed to lie among the fascicles of the ligament that have some type of proprioceptive or sensory function.[11]

Mechanoreceptors also have been identified on the surface of the ligament at the insertions of the ligament well beneath the external synovial sheath.

3.2 Why operate - Fate of an ACL deficient Knee joint:

There are 50% chances for associated *meniscal tears* with an acute ACL tear and 80% chances with chronic ACL tears. Lateral meniscal tears are common with acute ACL injury and medial meniscal tears are common with chronic ACL injury. Because of the increased chances of degenerative meniscal tears in the case of ACL deficient knee joints, 60% of the patients require meniscectomy at

the end of 5 years[12]. Also cartilage changes in the knee joint are twice as common in chronic ACL injuries(43%) in comparison to that of acute ACL injuries(20%)[13]. Multiple studies on the ACL deficient knees can be summed up with the Noyes et al,s Rule of thirds where one third of the patient will compensate adequately and will be able to pursue recreational activities, one third will be able to compensate but will have to give up significant activities and the rest one third will do poorly and will require future reconstructive surgery.[14]

Authors also have considered the hours of pre-injury sports activities and the degree of laxity of the ACL deficient knee as assessed by the KT-1000 arthrometer and formulated the Surgical Injury Risk Factor ("SURF") to decide on the management for acute ACL injuries.[15]

Table 1: **SURGICAL INJURY RISK FACTOR**

Anterior – translation of tibia on KT-1000 testing	**< 50 hours / year of Level I or II sports**	**50-199 hrs / yr of Level I or II sports**	**>/=200 hrs / year of Level I or II sports**
< 5 mm	Low	Low	Moderate
5 – 7 mm	Low	Moderate	High
> 7 mm	Moderate	High	high

3.3 Graft Selection:

3.31Bone-Patellar tendon – Bone: (BPTB)

The main advantage of using BPTB graft is that its initial graft strength is comparable or equivalent to that of the normal ACL. Bone to bone healing within the femoral and tibial tunnels is good and it gets incorporated in 6-8weeks time. The disadvantages with the graft is incidence of patella-femoral pain(12-40%), quadriceps weakness, numbness lateral to the incision due to injury to infra-patellar branch of saphenous nerve, patellar tendon rupture, tendinitis and patellar fracture. Bach et al after a 5-9 year follow up of post BPTB reconstruction reported 84% negative pivot shift, 2% had instability and 13% had patellar pain[16]. Shelbourne et al followed up 140 athletes who under went BPTB reconstruction reported 94% had no instability, 87% of them were able to get back to their pre-injury sports level. There was a higher prevalence of postoperative kneeling discomfort ($p < 0.01$) and an increased area of decreased skin sensitivity ($p < 0.001$) in the bone-patellar tendon- bone graft[17].

3.32 Hamstrings:

The quadruple hamstring tendon has an ultimate tensile load of 4108N, which is three times more than that of the normal ACL and has a stiffness of 807N/mm, which is also thrice that of the normal ACL. The graft side morbidity and the chances of extensor mechanism (quadriceps) weakness are reduced with the use of hamstring tendon. The main disadvantage of the graft is the relatively poor healing of the graft within the bony tunnel. There was a higher prevalence of femoral tunnel widening ($p < 0.01$)[18].

ACL reconstruction with ST-G grafts has a 38% incidence of squatting/kneeling pain that occurs secondary to patellofemoral crepitus, harvest site symptoms, and tibial hardware sensitivity[1]

3.33 Quadriceps-patella-bone complex:

The main advantage of using this graft is the incision which is at the proximal pole of patella thus avoiding chances of injury to the infra-patellar branch of saphenous nerve. Also bone to bone healing is possible on one end of the tunnel.

Fulkerson studied 60 cases with quadriceps tendon graft for a period of two years and found no statistical difference in complications. Griffith et at reported no difference in outcomes of patients with quadriceps graft or BPTB graft at the end of 1 year follow-up. Lee S et al reported showed satisfactory results with reduced donor-site morbidities in 67 patients who underwent reconstruction using quadriceps tendon at the end of 41 month follow up[19].

3.34 Allografts:

The advantages of using allograft are absence of graft side morbidity, smaller incision and decreased operative time. The increased chances of disease transmission, increased time for graft incorporation will be the disadvantages of using allografts as the graft for ACL reconstruction. Allografts include tendo-achilles tendon, bone-tendon bone , tibialis anterior and tibialis posterior tendons.

3.35 Synthetic grafts

They include the use of Dacron & Stryker grafts and 3M LAD(ligament augmentation devices. These are currently not in vogue.

3.36 Choice of graft:

Semitendinosus graft is generally indicated in skeletally immature patient, female patients with small patellar tendon, patients with pre-existing patello-femoral disease, revision of failed BPTB reconstruction and augmentation in a repairable native ACL. Also athletes, bikers, ballet dancers, skiers and jumpers are also compromised by a graft selection that utilizes extensor mechanism for reconstruction. It is also preferred in individuals who require to kneel habitually.

3.4 Graft Site Morbidity:

With the use of BPTB graft, Sach,s et al has reported a flexion contracture in 24%, patello-femoral pain in 19% and quadriceps weakness in 65% of their patients. Devastating complications such as patellar tendon rupture,fracture, patellar dislocation and patellar entrapment syndrome can also occur. Yasuda et al has reported 19% reduction in hamstring strength when Semitendinosus and Gracilis tendons were used for reconstruction[20], while Cooley et al reported <3% decreased hamstring deficit with harvest of semi-tendinosus alone for reconstruction.

3.5 Graft Strength:

Noyes et al reported that a 14mm B-PT-B graft had 168% of native ACL strength. This value fell to 120% of strength for a 9 – 10mm graft. Also he reported 70% of native ACL strength with single stranded semitendinosus tendon as compared to 250 % of ACL strength following a quadrupled tendon graft. The cross sectional

area of 9mm quadrupled semitendinosus autograft is between 60mm^2 – 70mm^2 when compared to 40mm^2 of a 10mm BPTBgraft. Therefore the quadrupled semitendinosus tendon is stronger than BPTB graft and also is closer in linear stiffness when compared to the native ACL.

The following table gives the bio-mechanical properties of ACL grafts according to the study done by Noyes FR, Butler DL, Grood ES, et al[2]

Table 2: BIO-MECHANICAL PROPERTIES OF ACL GRAFTS

	Ultimate strength (N)	Stiffness(N/mm)	Cross sectional area(mm2)
Intact ACL	2160	242	44
B-PT-B(10mm)	2376	812	35
Quadruple hamstring	4108	776	53
Quadriceps tendon (10mm)	2352	463	62
Tibialis Anterior (single strand)	3412	344	38
Tibialis Posterior (single strand)	3391	302	48

While some believe in the biological advantages of a multistranded hamstring graft compared with a bone-patellar tendon-bone graft[21,22], it is well accepted that healing of the tendon to bone is more difficult to achieve and requires more time (usually eight to twelve weeks) than does healing of bone to bone (usually four to six weeks)[23-25]. The attachment zone is said to be also more physiological with the bone-patellar tendon-bone graft with a regular chondral transition between tendon and bone[26], whereas in the hamstrings a fibrous insertion is usually obtained[25,27]. The factors that may determine the strength and stiffness of the tendon-fixation device-bone complex after implantation are the tendon graft-tunnel interface and the fixation device itself.

LITERATURE REVIEW ON CHOICE OF GRAFT:

Sajovic M et al in a prospective randomized comparison of *semitendinosus and gracilis* tendon vs *patellar tendon* grafts for anterior cruciate ligament reconstruction in 64 patients operated during the period of June 99- March 2000, (32patients underwent reconstruction using bone-patellar tendon bone graft and 32patients underwent hamstring tendon reconstruction) found at the end of a 5 year follow up, that there was no statistically significant difference in Lysholm score, clinical and KT-2000 arthrometery laxity testing, anterior knee pain, single-legged hop test, IKDC values, or graft failure rates. However, patients with

patellar tendon grafts had a greater prevalence of osteoarthritis at 5 years after surgery[18]

Beynnon BD et al on the other hand, at an average of 39 months follow up, with 22 patients in each arm (*BPTB*, and *double stranded semitendinosis)* that the objective results of anterior cruciate ligament replacement with a bone-patellar *tendon-bone autograft were superior to those of replacement with a two-strand semitendinosus-gracilis graft with regard to knee laxity, pivot-shift grade, and strength of the knee flexor muscles.* However, the two groups had comparable results in terms of patient satisfaction, activity level, and knee function[28]

In a prospective randomized clinical trial comparing results of the grafts, *BPTB* and double *semitendinosus and gracilis* tendon grafts, **Aglietti** et al followed up 120patients for a period of 2 years. He found to no differences in the visual analog score, the Knee Injury and Osteoarthritis Outcome Score, the new International Knee Documentation Committee subjective and objective evaluation scores, the KT-1000 side-to-side laxity measurements, the Functional Knee Score for Anterior Knee Pain, muscle strength recovery, or return to sports activities. In the *bone-patellar tendon-bone group*, he found a higher prevalence of *postoperative kneeling discomfort ($p < 0.01$) and an increased area of decreased skin sensitivity* ($p < 0.001$). In the *hamstring tendon group*, he recorded a higher prevalence of *femoral tunnel widening* ($p < 0.01$)[29]

Liden M assessed 71 patients out of which 34patients with *BPTB* grafts and 37 patients with *quadriceps tendon* after 7 years post-operatively using Lysholm score, Tegner activity level, International Knee Documentation Committee evaluation system, 1-legged hop test, KT-1000 arthrometer laxity measurements, manual Lachman test, and range of motion as assessment criteria. He also observed presence of *donor site morbidity in the form of knee-walking ability, kneeling ability, and area of disturbed anterior knee sensitivity*. No differences in outcome and donor site morbidity in the two groups were found[30]

Jannsson KA et al in his clinical, radiological and MRI study on bony tunnel enlargement after *hamstring tendon graft* for ACL reconstruction examined 14 patients at 3months, 1year and 2years post-operatively and compared with age matched controls with *B-PT-B* grafts. He collected data on clinical examination, laxity and isokinetic muscle torque measurements, anteroposterior and lateral view radiography and knee scores (Lysholm and Tegner) . Contrast-enhanced MRI was performed in the STG-endobutton group. There were no statistical differences between the groups with respect to clinical findings, stability tests, or knee scores. In the STG-endobutton group, the average femoral and tibial bone tunnel diameter detected on anteroposterior view radiography had increased at 2-year follow-up by 33% and 23%, respectively. The MRI results suggest that enhancing periligamentous tissue accumulated in and around the STG graft associated with the tunnel expansion. In spite of the *significant bone tunnel*

*enlargement observed on the follow-up radiography the STG-endobutton k*nees were stable and the patients satisfied.[31]

Tashiro et al in his study on the influence of medial hamstring tendon on knee flexor strength after ACL reconstruction evaluated 90patients who underwent ACL reconstruction using *semitendinosus tendon* alone and some with *semi-tendinosus and gracilis* tendons for quadriceps and hamstring muscle strength at 6,12,18 months post-operatively and revealed significant decrease in hamstring muscle strength in both the groups. He concluded that tendon harvest causes *significant weakness of hamstring muscle strength at high knee flexion angles, but such weakness can be minimized if the gracilis tendon is preserved*[32]

Goradia VK et al in his study on sheep models to describe the histologic structure of the intraarticular segment of a semitendinosus tendon autograft used for anterior cruciate ligament reconstruction over the first year after surgery. They performed an anterior cruciate ligament reconstruction in a single hindlimb of 11 sheep using a doubled semitendinosus tendon autograft secured to the femur with an endoscopic button and polyester tape and to the tibia with sutures tied around a screw. The *histologic structure* of the intraarticular segment of the graft at 4, 8, 12, 24, and 52 weeks after surgery was compared with that of the normal semitendinosus tendon and anterior cruciate ligament. The random collagen fiber orientation progressed to a longitudinal orientation from the peripheral to the central areas of the graft over the initial 12 weeks after surgery. A uniform

sinusoidal crimp pattern similar to that seen in the normal anterior cruciate ligament was identified under polarized light in nearly one-half of each graft by 24 weeks. Further maturation was noted at 52 weeks. Graft necrosis was not evident at any time period. This study showed *that semitendinosus tendon autografts transform into a histological structure similar to that of the normal anterior cruciate ligamen*t over the initial year after surgery, as has been described for patellar tendon grafts[33]

Armour et al hypothesized that internal tibial rotation strength may be affected when the hamstring tendons are utilized for reconstruction. 30patients with 2year post-operative follow up with stable ACL with anterior drawer's<5mm side to side difference and a normal contralateral knee were evaluated for internal rotation strength at different angular velocities and with the knee at 90degrees flexion.The mean torque measurements for internal rotation were significantly reduced while that of external rotation were equal when compared to that of the contralateral normal limb suggesting that with use of autogenous hamstring tendons there is demonstrable weaker internal rotation post-operatively(h) Viola et al also evaluated tibial rotation torques using Cybex NORM dynamometer and had similar results[34]

Literature on Proprioception:

In literature the terms kinaesthesia, joint position sense and proprioception are often used synonymously. In this study, we assessed the proprioception of the ACL deficient knee, and the contra lateral 'normal knee', and compared them with the proprioception in knees of healthy volunteers – both in terms of on kinesiology and joint position sense.

Barrett DS et al studied three groups - normal controls, patients with ACL deficient knees and patients who had undergone ACL tendon reconstruction and assessed *joint position sense* as a proprioceptive indicator. 45 patients with an average age of 26.4 were followed up 3.4 years post-operatively with functional scores, Lysholm, Tegner and ligament laxity tests and tests for *proprioception. ACL deficient knees showed significant decrease in joint position sense when compared with age matched ACL reconstructed knees ($p<0.02$) and that of normal knee*s ($p<0.01$). The improvement in proprioception in the ACL reconstructed knees correlated well with patients' satisfaction and functional outcome.

Joint position sense was significantly improved by cruciate reconstruction, although no changes were made to the basic receptors for proprioception by the operation. Following an anterior cruciate rupture, proprioceptive sensation must arise from undamaged collateral and capsular receptors. As the anterior cruciate deficient knee moves in a non-physiological axis, alteration in gait and movement

follow (Berchuck et al 1990). Thus, the remaining proprioceptive output will be non-physiological and disorganized. Patients feel the knee to be unstable because cortical interpretation and analysis of knee position is disturbed. By restoring physiological movement by anterior cruciate reconstruction, cortical interpretation is probably enhanced and the sensation of improved stability seems to follow[35]

Fremerey et al assessed proprioception using *angle reproduction* test devised by Barrett et al. He studied three groups of people- 20 normal subjects, 20 patients with ACL deficient knees and 20 patients who had undergone ACL reconstruction with bone-patellar tendon-bone autograft. *Both the normal and index knees revealed increased deviations in angles in proprioception when compared to the normal control groups*. In the operated group, the proprioception at the end of 3 months was less than that of the pre-operative values, but at the end of 6 months proprioception had significantly improved. *High co-relation was found between the patient's satisfaction and proprioception*.[36]

Anders used the *angle reproduction method and single leg hop test* to evaluate proprioception in post-op patients following ACL reconstruction using B-PT-B graft. 45 patients in the age group 19-52years at a 36month follow up were evaluated and found to have *significant difference in the angle reproduction test when compared to contralateral normal knees*, After ACL reconstruction, differences in the angle reproduction test between the two sides were very small

but were still observed. Over all the proprioceptive and functional outcomes were improved.[37]

Al-othman et al in his study on proprioceptive function in 32 ACL deficient knees, 22 ACL reconstructed knees and 30healthy controls using simple standing leg test “Al-othaman’s test” (ability to reposition the limb to the reference O line) demonstrated significant difference in proprioceptive functions between the ACL deficient knees and the ACL reconstructed group (<0.05). No significant difference between the normal control group and the ACL reconstructed knees were observed. He concluded that the proprioceptive deficits as measured clinically with his test improves after ACL reconstruction.[38]

Roberts D et al studied the proprioceptive function of 20patients who underwent ACL reconstruction and compared it with that of 19 normal controls. Three tests of proprioception were used: (a) threshold to detection of passive motion from 20 and 40 degrees toward flexion and extension, (b) active reproduction of a 30 degrees passive angle change, and (c) visual reproduction of a 30 degrees passive angle change. The data revealed decreased proprioceptive ability was present in some measurements of these patients after reconstructive surgery, *not only in injured knees but also in uninjured knees*, as compared with the reference group. The results suggest that bilateral proprioceptive considerations should be made when evaluating prognostic factors, treatment, and risk of contralateral knee injury in patients with reconstructed anterior cruciate ligaments.[39]

Lee et al analyzed the results of anterior cruciate ligament reconstruction using the remnant-preserving technique with the use of a hamstring graft. 16 patients were operated using the remnant preserving technique and at the end of 35 months follow up the patients were evaluated with the International Knee Documentation Committee scale and Hospital for Special Surgery score as subjective tests; stress radiographs, Lachman test, and anterior drawer test by use of the KT-2000 arthrometer (MEDmetric, San Diego, CA) as objective tests; and single-legged hop test, reproduction of passive positioning, threshold to detection of passive motion, and single-limb standing test as functional tests. He confirmed that the *remnant-preserving technique resulted in good proprioceptive and functional outcomes*[40]

Ozenci et al followed up the proprioception of four groups of patients(normal controls, with allograft ACL reconstruction, with autograft ACL reconstruction and patients with ACL deficient knees.) *TDPM and JPS were evaluated* with a dynamometer. There was a *significant difference in TDPM between patients with injured ACLs* and the other three groups (injured: 1.93 degrees vs. control: 1.03 degrees , autograft: 1.01 degrees , allograft: 0.96 degrees ; $P < 0.001$). Proprioception in Auto and allograft reconstructed knees was not significantly different from each other or controls. Most importantly, they found that *proprioception did not correlate with postoperative anterior knee laxity*. Many variables are involved in joint proprioception and the anterior knee laxity may not

be the sole determining element. A lax ACL may still fulfill some of its afferent arc functions as long as it bridges the femur and tibia.[41]

However, there have been several other authors who have stated that there is no change in the proprioception of the joint following ACL injury.

MacDonald PB et al compared and quantified the proprioceptive function of the patients in three groups, *patients with ACL deficient knees, patients whose ACL reconstructed using Hamstring tendon graft and the last group whose ACL was reconstructed using BPTB graft*. 32 patients including 6 un-injured controls were assessed for threshold for detection of passive motion. The contralateral knee was taken to compare the affected knee joint. The variables of age, KT-1000 arthrometer scores, injury-to-surgery interval, injury-to-follow up interval, and patient satisfaction were statistically analyzed for correlation with threshold to perception of passive motion of the knee. Control subjects showed no statistically significant differences in threshold between their two knees. The three test groups *all showed significantly higher values in the involved knee compared with the noninvolved knee* ($P < 0.01$). However, no statistically significant differences were found between the groups, including controls, with respect to mean threshold to perception of passive motion. He concluded that ACL reconstruction does not improve proprioception of the knee joint.[9]

Jerosch J et al evaluated the proprioceptive function of the knee joint using the *angle reproduction method*. 25 patients with an isolated rupture of the anterior cruciate ligament were evaluated. Fourteen patients were examined preoperatively 11 after operative ACL reconstruction. Preoperatively proprioception was significantly poorer than in the control group. They were able to show a positive influence of a knee bandage on the proprioception of the injured knee as well. *Patients after ACL reconstruction did not show a significant improvement in proprioception.*[10]

METHODOLOGY:

Inclusion Criteria:

- Men between 18-40 years
- First ACL reconstruction surgery
- Single leg involvement

Exclusion Criteria:

- ACL injury less than 6 weeks.
- Other associated injuries (eg. Fractures, other ligaments involvement, neurovascular bundles injury).
- Significant OA changes
- Known chronic disease affecting proprioception like Diabetes, peripheral neuropathy or vestibular dysfunction.
- Neurological deficits
- Bilateral ligament injury
- Re-do ACL reconstruction.

All the patients with ACL deficient knees who fitted the above criteria were assessed pre-operatively using the following assessment tools:

1. Subjective IKDC scores (Appendix 1)
2. Objective IDKC scores (Appendix 2)
3. Objective functional tests - single hop, and the triple hop test (Appendix 2)
4. SF36 – to assess the impact on the quality of life. (Appendix 3)
5. Lysholm scores (Appendix 4)
6. Tegner Activity score (Appendix 5)

All the patients had an arthroscopic reconstruction of the anterior cruciate ligament using the quadrupled hamstring tendon. All had the same post op physiotherapy protocol (Appendix 6) and were reviewed 1 year postoperatively with the same assessment tools.

1. Subjective IKDC scores:

This is a questionnaire in which patient grades his symptoms like pain, swelling, and giving way and also his ability to do specific activities such as stair climbing up and down stairs, squatting, kneeling down, rising up from chair, running straight ahead, jump and land on the involved knee joint. Each activity is graded from 0-4 to get a final subjective score.(maximum score of 87 is normalized to 100.)

2. Objective IKDC Scores: This includes the assessment of effusion, range of motion at the joint, antero-posterior and medio-lateral translation of the knee joints, pivot shift test and the patellar pain on kneeling test.

Effusion:

An effusion is assessed by balloting the knee joint. A fluid wave (less than 25cc) is graded as mild, easily ballottable fluid – moderate(25-60cc) and a tense knee secondary to effusion (greater than 60cc) is rated severe.

Passive Motion deficit:

Passive range of motion is measured with a goniometer and recorded on the form for the index side and the normal side. Extension is compared to that of the normal knee joint.

Ligament Examination:

The Lachman test, Anterior drawer test, Posterior drawer test, medial and lateral opening and Pivot shift tests are done both for the index and the normal side.

Lachman test: The test is done in 15degrees of knee flexion. When the index knee has 3-5mm more anterior laxity than the normal knee, and in case a soft end point is present, an abnormal grade is recorded.

The drawer test: The anterior and posterior drawer's tests are done with the knee in 70 degrees of flexion and the hamstrings relaxed. The degree of anterior/posterior translation is recorded and graded accordingly.

Valgus/varus stress test: The varus/valgus stress test are done with the patient lying down supine and the knee at full extension and at 30 degrees knee flexion and accordingly graded.

Pivot Shift test: Pivot shift test is done with hip in 10-20degrees abduction and tibia in internal rotation using Hughston and Losee test and is graded as equal, glide, clunk and gross.

Patellar pain on kneeling: The patient is advised to kneel down on to the ground unsupported and pain is graded as A. - can kneel for >15secs without pain, B - <15secs, C- <5secs and D- cannot kneel down.

3. **Objective Functional tests** –

The single hop test is part of the IKDC battery of tests.

HOP TESTS:The patient is asked to perform a one leg hop for distance on the normal side first followed by the index side . Three trials for each leg are recorded and averaged. A ratio of the index to normal side is calculated and documented to various grades for the *single hop test*. Similarly the triple hop test is also recorded, averaged and calculated. This is not included in the IKDC however.

4. SF 36:

This is a standardized health questionnaire to subjectively assess the generalized health of the patient in terms of physical and psychological health. The scores are taken both pre-operatively and post-operatively.

5. Lysholm scores:

The Lysholm score is a subjective score which assesses the current function of the knee joint and it involves questions on squatting, stair climbing, locking episodes, giving way, pain, swelling in relation to activities, the presence of limping and the need to use of crutches for ambulation.

6. Tegner activity score:

The Tegner activity score involves a subjective assessment of the current activity status of the patient eg. Walking, jogging on uneven surface, playing tennis, basketball etc. and the activity level is scored accordingly. The patient is asked to reassess his activity score a year later.

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Assessment of Proprioception:

In this study, the proprioceptive function of the affected knee joint, contralateral 'normal' joint, and normal joints of healthy volunteers were assessed in terms of kinesthesia and joint position sense preoperatively.

The following tests were done to assess proprioception.

Joint position sense test (JPS). This test measures the ability to reproduce passively the position of the lower leg. Starting at a free-hanging position of 90°,the motor moves the subject's leg at a rate of 3°/s to three angles – 30, 45

and 60° of flexion. The leg is held in this position for a few seconds and the subject is asked to concentrate on its position. The knee is returned to the starting position and then moved again by the motor at a speed of 3°/s. When the subject thinks that the leg is in the same position as before, he stops the motor by using the on-off switch of the motor control box. The absolute angular error is measured. This procedure is repeated three times for each angle, and a mean value of angular error is recorded for each subject.

Kinaesthesia test (KT). The threshold of detection of a passive leg movement is measured. A wire, wound up by a slow-speed motor, is attached to the side arm connected to the foot frame moves the subject's leg (Fig. 1). From a starting position of 70° of knee flexion, the motor slowly pulls the subject's leg into extension at 0.2°/s. The subject is given a control box with an on-off switch to stop the motor when a change is perceived in the position of the tested leg. This procedure is repeated 3 times and the mean threshold angle to detect passive movement is recorded for each subject. Similarly from a starting position of 30° of knee flexion, the procedure is repeated 3 times and the mean threshold angle is detected.

For standardization in this study, the subject's leg is allowed to hang freely over the side of the chair, at a distance of 5 to 10 cm proximal to the popliteal fossa. The thigh is strapped to the chair, To reduce errors, visual clues are eliminated using a blindfold. Auditory clues are eliminated by using earmuffs/ cd music

playing. A stockinet is applied as tightly as possible to the leg, to neutralize cutaneous sensation and held in an adjustable polypropylene AFO with straps). A wire, wound up by a slow-speed motor, is attached to the side arm that holds the foot frame. This motor moves the subject's leg at a predetermined rate for the experiment.

Balance master test

This is a dynamic test used to assess proprioception while weight bearing on a force plate. The subject stands on a force plate - on a single limb, with eyes closed, and arms crossed over the chest. The degree of sway in the A-P axis, transverse axis and the velocity moment is calculated. This gives an idea of the amount of sway while standing on the single limb – which is a reflection of the joint proprioception.

Surgical Procedure:

Graft Harvest:

Patient is positioned supine with the affected leg hanging over the edge of the table and the well leg draped out of the surgical field. A 2-3 cm longitudinal skin is incision made over the pes tendons beginning 1-2cm medial to the tibial tuberosity. The Sartorius aponeurosis is identified and the underlying tendons are identified. The aponeurosis is cut and the semitendinosus tendon is isolated and separated from the gracilis tendon. A running whipstitch is made with 5- 0 ethibond at the free end. The deep fascial bands to the gastrocnemius fascia are

released with scissors. With the knee flexed 70 – 80 degrees, gentle traction maintained on the distal free edge, the stripper is advanced proximally in line with the tendon, to harvest the semitendinosis tendon.

Graft Preparation:

Tendon length is measured and then the tendon is sharply divided in to two on the preparation board and whip stitched on to the remaining three free ends are whip stitched. The grafts are doubled to make the quadrupled hamstring graft and passed through the sizing bar to measure the diameter of the graft. The graft is tensioned to 15-20 Newton for a period of 15 mins and then the endobutton device is loaded.

Tunnel Preparation:

Tibial tunnel is prepared first. The guide tip is positioned intra-articularly through the antero-medial portal. It is angulated 45degrees to the anterior cortex of tibia, 4 cm below the joint line. A cannulated reamer similar to the measured diameter of the graft is used to create the tibial tunnel. The exit point is at the ACL footprint, 7 mm in front of the PCL origin.

The femoral tunnel is prepared next using a 5mm offset from the posterior femoral cortex just distal to the level of “over the top” position with the knee joint 100 degrees flexed at the $10^{‘0}$ clock position in the right knee joint and $2^{’o}$ clock position in the left knee joint. Intra-articular graft length is measured to aid in the endobutton measurement. The femoral guide pin is drilled through the antero-

lateral cortex of distal femur and a 4.5mm endoscopic cannulated reamer used to drill the femoral tunnel. This is for the passage of the endobutton. The femoral canal is drilled to the same predetermined diameter as the graft – for a distance of 0.6-1 cm more than the calculated femoral segment of the graft.

Graft passage and fixation:

The graft with the endobutton and the attached vicryl and ethibond stitches are passed through the eyelet of the guide pin and it is pulled slowly till the endobutton gets flipped. The graft is pulled distally to confirm the final seating of the endobutton on to the antero-lateral surface of distal femur. With the knee in neutral, the quadrupled hamstring tendon is tied under tension, around a tibial fixation post with washer - which is fixed below the exit point of the graft on the tibia.

Post-operative period:

Post-operatively patient is started on static quadriceps exercises and gentle range of motion exercises. Antibiotics and analgesics are given for a period of 48 hours post op. Rehabilitation is started according to the standard protocol (Appendix 6):

Results Of ACL Reconstruction

Total Number of Patients - 21 (males)

Mean Age of patients - 28.38 years (18 – 40 years)

Mean Time of follow up - 12 months (9-15months)

Right sided ACL deficient pts. - 13

Left sided ACL deficient pts. - 8

Mode of Injury:

Sports activities - 14

Road Traffic Accident - 7

Pre-operative Symptoms:

Pain - 14

Instability - 21

Swelling - 6

Locking - 6

Meniscal Involvement :

Medial meniscus	-	5
Lateral meniscus	-	1

Articular cartilage status	-	1 patient had a central defect in both medial & lateral condyles
Mean duration of injury	-	13months before surgery.
Range	-	2 – 108 months

Table 3: **POST-OPERATIVE FOLLOW UP:**

SCORES	Pre-operative	Post-operative
IKDC SUBJECTIVE (0-100)	54.96	80.57
LYSHOLM (0–100)	54.5	89.8
TEGNER ACTIVITY SCORE (0-10)	2.3	5.52
SF-36 (physical) (19-64)	32.62	37.14

Post-operatively, the average scores of both subjective and objective scores have showed a significant improvement(p value for subjective score = 0.000, p for lysholm = 0.000, p for tegner score = 0.000) implying a good outcome. The SF-36 score system (physical) also showed a significant improvement post-operatively (p value = 0.007)

Table 4 : **IKDC OBJECTIVE SCORES:**

Post-op → Pre-op ↓	A	B	C	D
A				
B				
C(2)	1	1		
D(19)	3	9	4	3

One patient gave a history of twist and fall at 6months post-operative period, and was not able to hop thereafter. One patient had a sub-clinical infection, and the another patient did not follow the post-op physiotherapy protocol and therefore had weak quadriceps power. Three patients remained IKDC D postoperatively. All had poor single hop tests. All the four patients under IKDC C had IKDC A Lachman test, but all 4 had a poor single hop test (IKDC grade C). All the patients pre-operatively had >5mm anterior translation(Lachman C/D, post-operatively none of them had > 5mm anterior translation.

Current Function of the Knee Joint:

(Subjective Function)

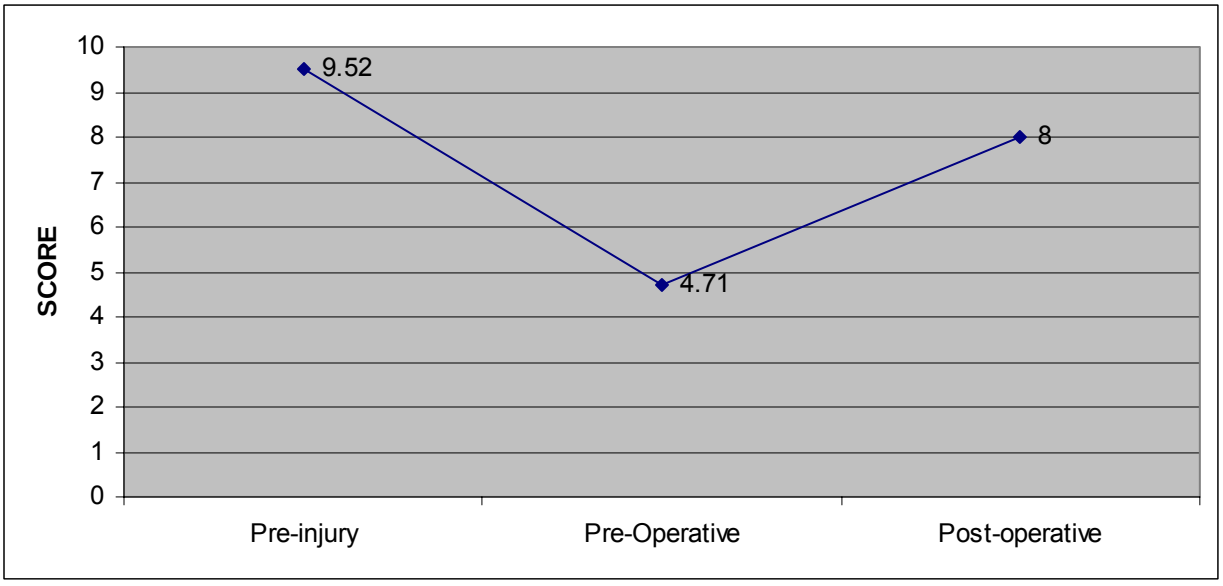
In the subjective score of the IKDC form, there was a question on the patient's overall assessment of global function of the knee joint. (score from 0-10) The graph below shows the patient's assessment of global function pre and postoperatively. There is a significant improvement in the subjective function post-operatively (p value = 0.000)

Pre-injury knee score - 9.52

Pre-operative score - 4.71

Post-operative score - 8

Graph 1: **Subjective Function of ACL Deficient knee joints**



Single Hop Test- (Range – 0-100)

Mean pre-op score - 59.6

Mean post-op score- 79.2

p value - 0.001

Triple Hop Test - (Range – 0-100)

Mean pre-op score - 56.6

Mean post-op score- 79.9

p value - 0.000

There was a significant improvement in the hop tests postoperatively

Table 5 : **RESULTS for Triple Hop test**

Post-op → Pre-op ↓	A (>/=90%)	B (89-76%)	C (75-50%)	D (<50%)
A				
B	2	2		
C	3	3	1	1
D	1	5	1	2

SUBJECTIVE SYMPTOMS

Locking :

No. of patients with locking pre-op. - 6

No. of patients with locking post-op. - 1

All the patients had associated meniscal injury(5 medial meniscus and 1patient with lateral meniscus) for which debridement and partial meniscectomy was done.

Stair Climbing:

	Pre-op	Post-op
Nil - Mild	16	21
Moderate – severe	5	0

(Nil/ mild – Lysholm >/= 6/10; moderate -severe – Lysholm <6/10.)

Squatting:

	Pre-op	Post-op
Nil - Mild	15	21
Moderate – severe	6	0

(Nil/ mild – Lysholm >/=4/5; moderate-severe – Lysholm <4/5)

Instability – Knee:

	Pre-op	Post-op
Rare	1	19
Occasional	5	2
Frequent	15	0

(Rare-Lysholm>20; occasional – Lysholm 15; Frequent – Lysholm <15)

One patient gave a history of a twist and fall at 6months post-operatively. There after he complained of mild giving way occasionally. The other patient who had occasional giving way had sub clinical infection postoperatively.

Pain:

	Pre-op	Post-op
Nil	4	19
Mild	9	2
Moderate – severe	8	0

(Nil – Lysholm >/=25;mild – Lysholm >/=15 moderate-severe – Lysholm <15)

Knee Swelling:

	Pre-op	Post-op
Nil - Mild	15	21
Moderate – severe	6	0

(Nil/ mild – Lysholm >/= 6; moderate -severe – Lysholm <6.)

Results – Proprioception Assessment in the ACL Deficient Knee Joints

Total number of patients	-	25
Total number of controls	-	25
Mean Age of patients	-	28 (18-38)
Mean Age of controls	-	28.3 (21-33)
Mean Duration from injury	-	2.5 years
No. of left ACL deficient knees	-	12
No. of right ACL deficient knees	-	13

TESTS FOR PROPRIOCEPTION:

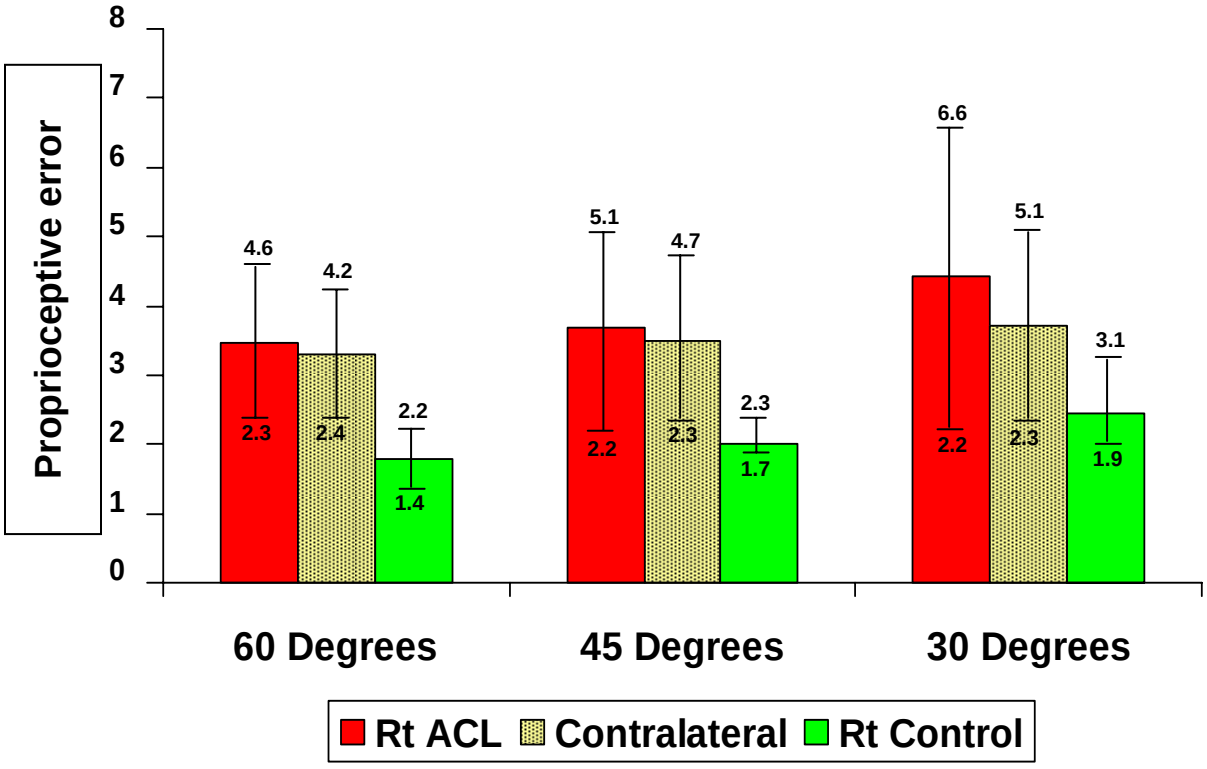
1.Joint Position Sense

2. Kinaesthesia (Threshold to detection of passive movement)

3. Balance Master test.

JOINT POSITION SENSE

Graph 2 : RIGHT ACL DEFICIENT KNEES



Angle of reproduction

The above graph is the response of passive reproduction of joint angle. The results shows significant proprioceptive loss in the ACL injured knee when compared to the control knee joint at all angles of reproduction i.e. 60, 45 and 30degrees.

Table 6:

Right ACL Deficient Knee Jnts – right knee joint Vs Controls

Angles (degs)	Patient (right knee) (mean)	Controls (mean)	p - value
30	3.46	1.78	0.008
45	3.69	2.01	0.02
60	4.43	2.46	0.10

There is also a significant proprioceptive loss in the 'contra-lateral' unaffected knee joint when compared to the controls.

Table 7:

Right ACL Deficient jnts – left Knee Joint Vs Controls

Angles (degs)	Patient (left knee) (mean)	Controls (mean)	p - value
30	3.33	1.95	0.01
45	3.50	1.88	0.01
60	3.70	2.40	0.11

However when comparing the proprioceptive loss between the ACL deficient knee joint and the unaffected knee, the error is not statistically significant.

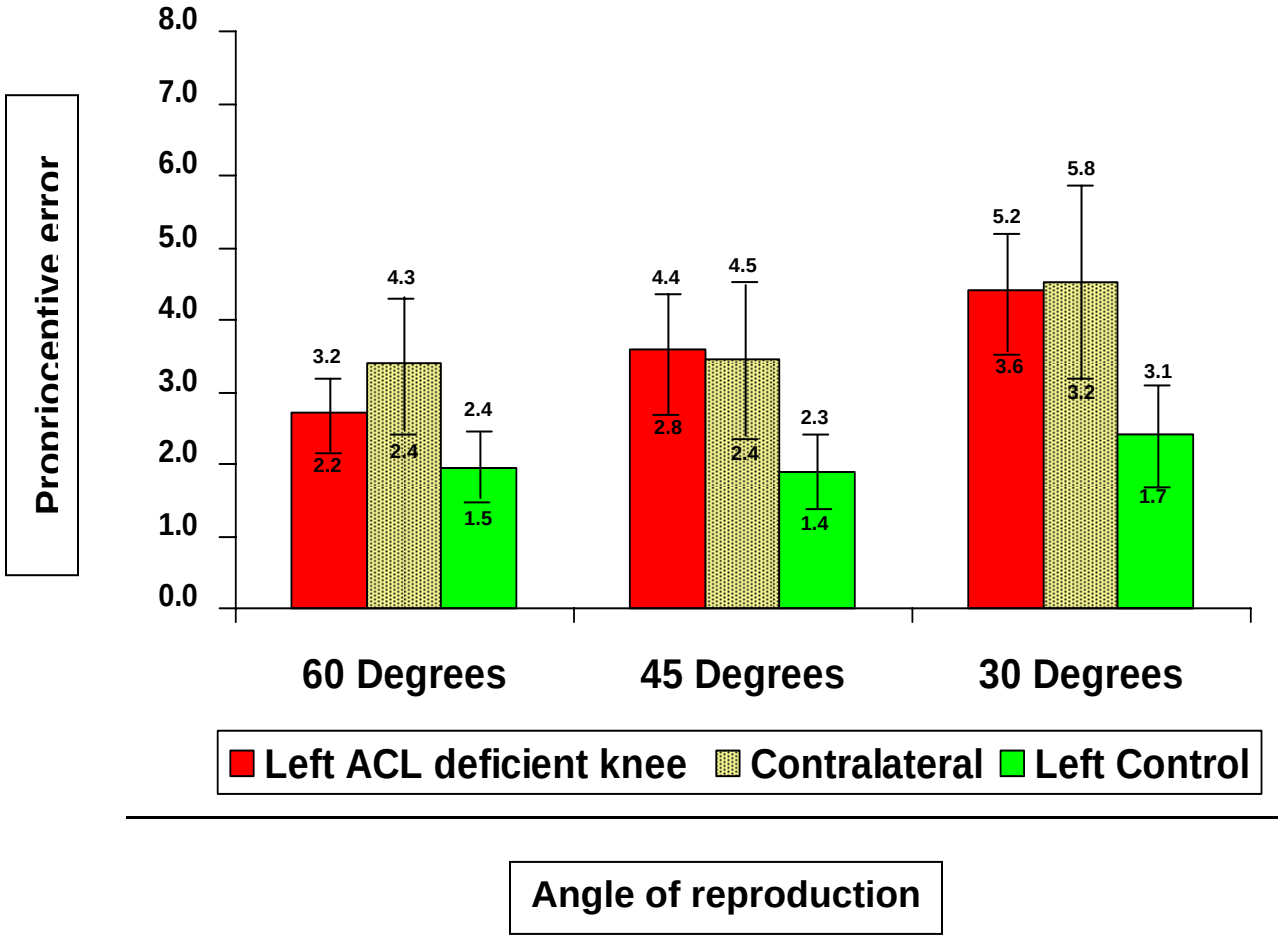
Table 8:

Right ACL Deficient Knee Joints Vs Unaffected Left Knee joints

Angles (degs)	Patient (Rt) (mean)	Patient (Lt) (mean)	p - value
30	3.46	3.33	0.83
45	3.69	3.50	0.81

60	4.43	3.70	0.32

Graph 3 : LEFT ACL DEFICIENT KNEES



The graph depicts the results of passive reproduction of joint angle of the left knee. The results shows significant proprioceptive loss in the ACL injured knee when compared to the control knee joint at 60,45 and 30degrees

Table 9:

Left ACL Deficient Knee Jnts - left knee joint Vs Controls

Angles (degs)	Patient (left knee) (mean)	Controls (mean)	p - value
30	2.71	1.95	0.03
45	3.60	1.88	0.001
60	4.40	2.40	0.001

There is also a significant proprioceptive loss in the 'contra-lateral' unaffected knee joint when compared to the controls..

Table 10:
Left ACL Deficient Jnts- right knee joint Vs Controls

Angles (degs)	Patient (right knee) (mean)	Controls (mean)	p - value
30	3.39	1.78	0.007

45	3.45	2.01	0.01
60	4.51	2.46	0.01

However when comparing the proprioceptive loss between the ACL deficient knee joint and the unaffected knee, the error is not statistically significant

Table 11:

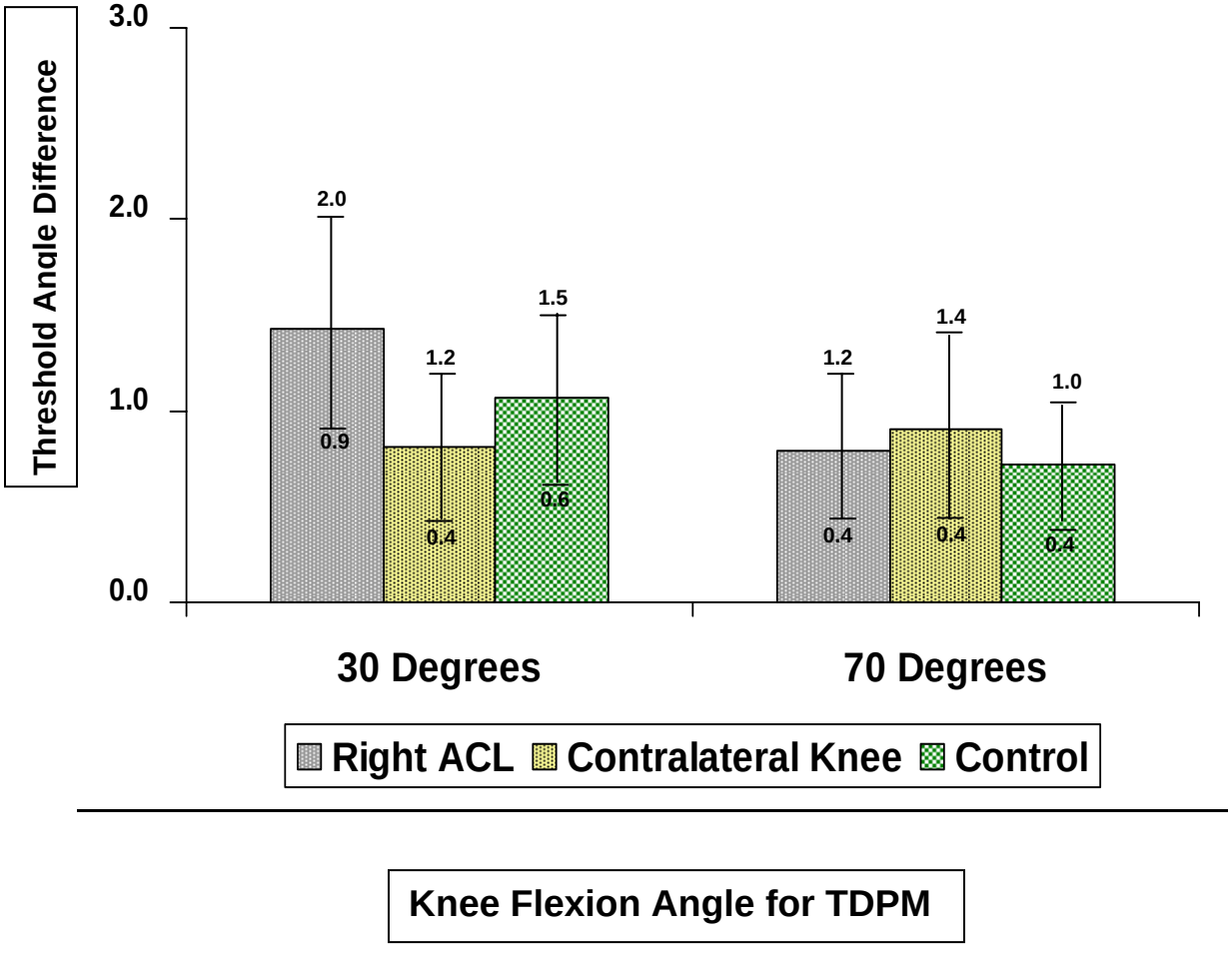
Left ACL Deficient Knee Joints Vs Unaffected Right Knee joints

Angles (degs)	Patient (Lt) (mean)	Patient (Rt) (mean)	p - value
30	2.71	3.39	0.19
45	3.60	3.45	0.71
60	4.40	4.51	0.84

KINAESTHESIA

(THRESHOLD TO DETECTION OF MOVEMENT)

Graph 4: RIGHT ACL DEFICIENT KNEES:



The above graph denotes the results of threshold to detection of passive movement. The threshold to detection of passive movement

of the ACL deficient knees are higher than that of the controls, but the values are not statistically significant.

Table 12:

Right ACL Deficient Knee Jnts – right knee joint Vs Controls:

Angles (degs)	Patient (right) (mean)	Controls (mean)	p - value
30	1.43	1.07	0.35
70	0.79	0.72	0.79

Table 13:

Right ACL Deficient jnts – left Knee Joint Vs Controls

Angles (degs.)	Left Knee (mean)	Controls (mean)	p- value
30	0.81	0.86	0.84
70	0.9	0.67	0.28

The above table does not show any significant difference in errors between the contralateral knee joint and that of the controls.

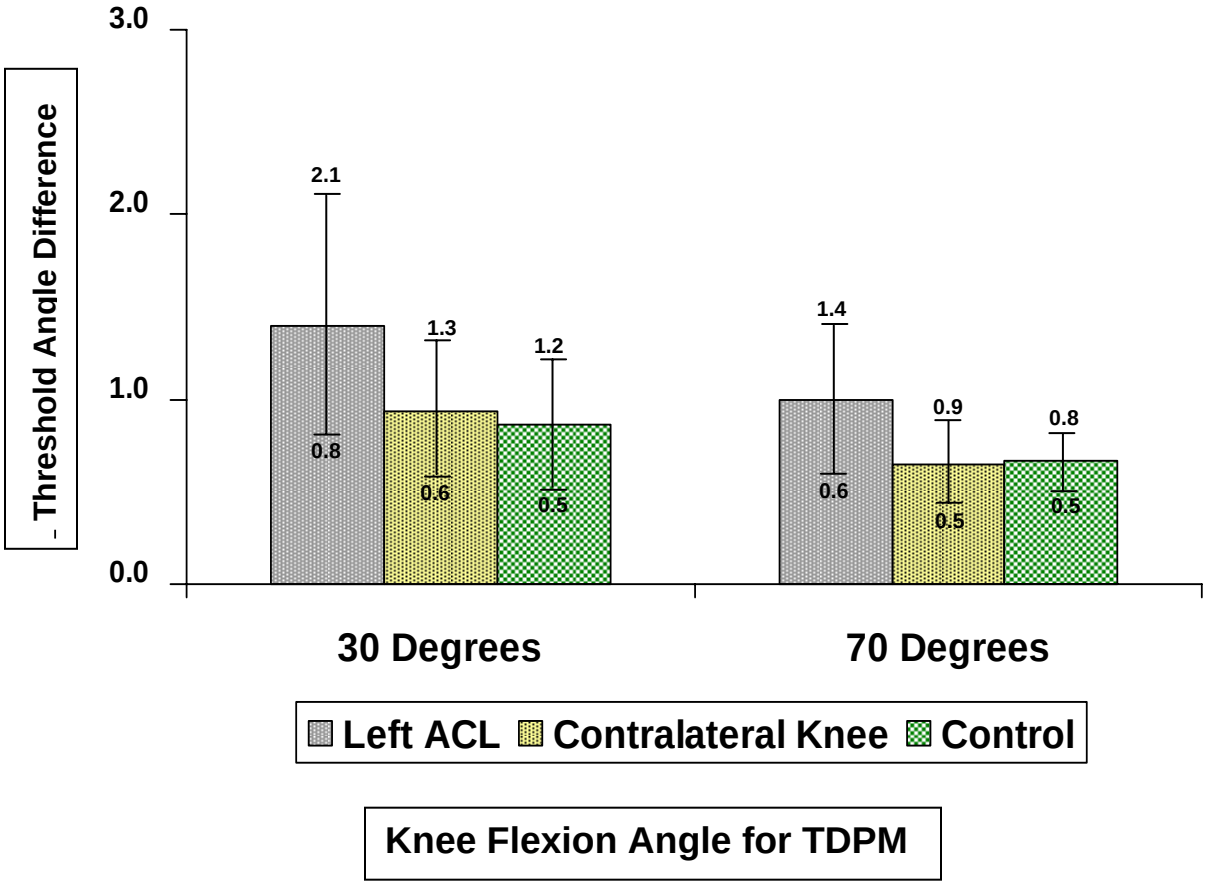
Table 14:

Right ACL deficient knee joints Right Vs Left:

Angles (degs)	Patient (Rt) (mean)	Left Knee (mean)	p- value
30	1.43	0.81	0.84
70	0.79	0.9	0.28

There was no statistically significant difference demonstrable between the ACL deficient and the unaffected contralateral knee joint of ACL deficient patients.

Graph 5 : LEFT ACL DEFICIENT KNEES



The threshold to detection of passive movement of the ACL deficient left knee knees are higher than that of the controls, but the values are not statistically significant

Table 15: Left ACL deficient Knee joints- left knee jt Vs controls

Angles (degs)	Patient (Lt) (mean)	Controls (mean)	p - value
30	1.44	0.86	0.07
70	1	0.67	0.07

Table 16:

Left ACL deficient Knee joints- right knee jt Vs controls

Angles (degs)	Patient (Contralateral Knee (mean)	Controls (mean)	p- value
30	0.93	1.07	0.69
70	0.65	0.72	0.78

Both the above tables did not reveal any statistical difference between the affected knees, unaffected contralateral knee joint and the controls.

Table 17:

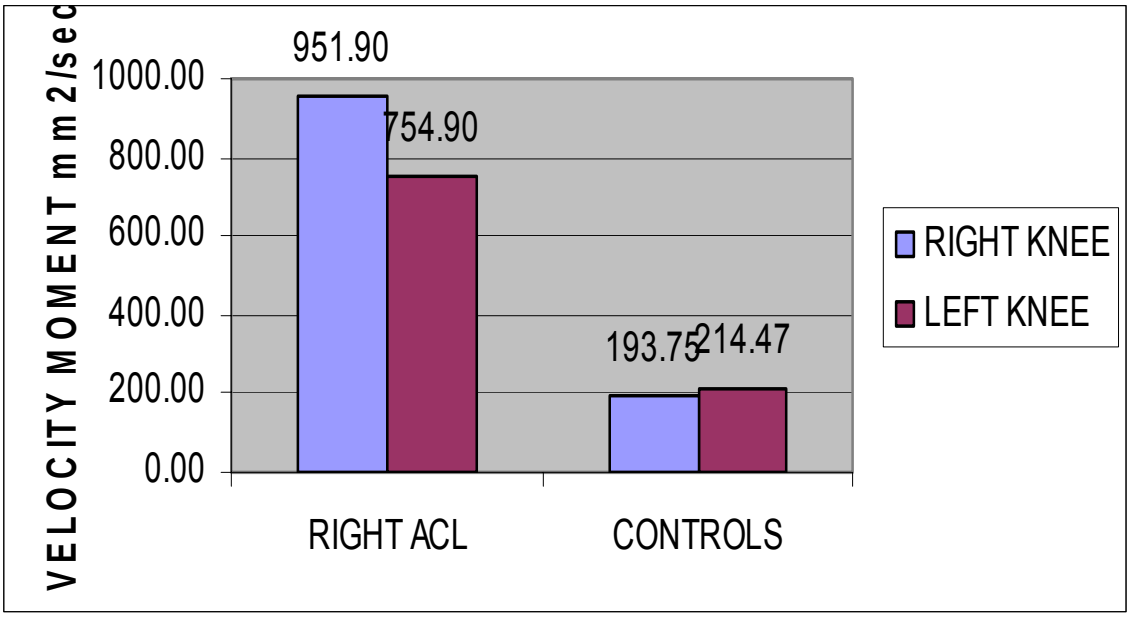
Left ACL deficient knee joints Left Vs Right

Angles (degs)	Patient (Lt) (mean)	Right Knee (mean)	p- value
30	1.44	0.93	0.08
70	1	0.65	0.19

The threshold to detection of passive motion test between the affected knee joint and the contralateral unaffected knee joint did not show any significant difference between the two.

BALANCE MASTER TEST

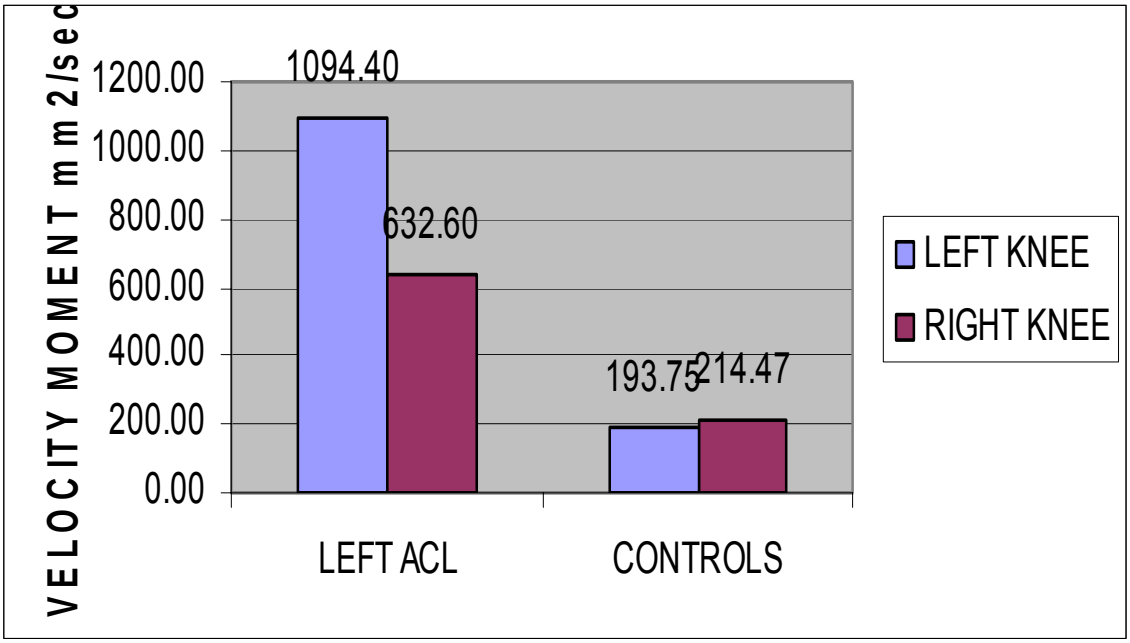
Graph 6: RIGHT ACL DEFICIENT KNEES;



The graph shows a higher degrees of sway and therefore higher degrees of proprioceptive loss between the patients knees (affected knee) and the controls.(p-value = 0.007).

In between the patient's affected knee joint and the contralateral normal knee joint, the difference was not much. However the significance needs to be assessed with large numbers.

Graph 7: LEFT ACL DEFICIENT KNEES:



The velocity moment of the patients unaffected left knee joint and the right affected knee joint is not significantly different . (p-value = 0.075) but the proprioceptive loss in the affected knee joint is significantly higher than that of the controls. (P=0.017).

Discussion

During the past decade, there has been an increased use of hamstring grafts with multiple strands to reconstruct the anterior cruciate ligament[43,44,45,46,47.] This trend is believed to be related to improved fixation techniques and the perception that hamstring grafts are associated with less morbidity than patellar ligament grafts [43,44,45,46,47,48]. Patellar ligament grafts continue to be popular because of their long record of providing stability; however, concerns associated with their use include pain at the donor site, chronic patellofemoral pain, loss of motion of the knee, quadriceps weakness, patellar fracture, and rupture of the patellar ligament[43,44,47,48,49,50,51].

In our study we audited the clinical and functional outcome of Anterior Cruciate Ligament reconstruction with Hamstring tendon graft. Of the 32 patients operated, 21 patients were followed up at 9 – 12 months post-operatively. All the patients were evaluated for outcome on the basis of anterior laxity, pivot shift test, subjective outcome(patient satisfaction), activity level(return to sports, tegner score) ,knee function (ability to do single hop, triple hop, squatting, climbing stairs) and knee movement.

Preoperatively, all patients had laxity of the knee – either C or D according to the IKDC criteria. Post-operatively, no patient had laxity of grade C or D. 57.1%(12/21) had Lachman's A, and the rest were Lachmans B . 71.4%(15/21) of patients had negative pivot shift test. The others had only mild pivot shift. Lachman test was done by the investigator and was checked by a orthopaedic consultant Three of the patients had a poor functional hop result on the objective IKDC scores. One of the patients had a fall and probably re-ruptured the reconstructed tendon, one had sub-clinical infection and the other was too scared and did not perform adequate physiotherapy and had a weak quadriceps at the time of assessment.

Howell in his study on double semitendinosus graft and gracilis graft studied 37patients and at the end of four months of the rehabilitation program, thirty-three (82%) of the thirty-seven patients had an absent pivot shift and a normal Lachman test[8] . Williams et al analysed the clinical outcome following quadrupled hamstring tendon graft reconstruction for ACL deficient knees, in 85 patients at a 2 year follow up. He found that 76(89%) of patients had negative lachman's test and negative pivot shift tests. The mean Lysholm score improved from 55 points preoperatively to 91 points at the time of follow-up ($p < 0.01$). The mean Tegner score improved from 5 to 6 points ($p < 0.01$). . Three patients (4%) had a positive pivot shift test but had no history of additional trauma to the knee. Six patients (7%) had a traumatic rupture of the graft, occurring at a mean of 10.7 Months postoperatively[52] . Most of the patients underwent a supervised post-

operative physiotherapy rehabilitation which played a vital role in the outcome.

In our 1 year follow up, patient satisfaction assessed using the IKDC subjective score improved from 47.1% to 80% and IKDC subjective score from 54.96 to 80.57. The Lysholm score increased from 54.5 to 89.8. Only 3 among the 21patients returned back to their pre-injury sports level. A large number of the remaining patients, in spite of a good hop test and negative pivot shift test, were scared to get back to their pre-injury sports level. They were scared of 'giving way', of undergoing surgery again and henceforth had reduced their demand and did not return to sports. In Howell's study, the level of sports activity significantly improved following the operation ($p = 0.009$) but was not restored to the pre-injury level ($p = 0.01$).Thirty-eight (93 per cent) of the forty-one patients had returned to either strenuous (twenty-five patients;61 per cent) or moderate (thirteen patients; 32 %) activities by two years after the operation.[8]

In spite of the poor functional hop tests, and relative laxity, in our patients, Tegner activity score increased from 2.3 to 5.52. When comparing the triple hop tests the mean score improved from 56.6 to 79.9. Out of the 6 patients with grade A on the IKDC triple hop test (>90% of the opposite side), 3 of them had Lachman A laxity and the rest had Lachman B laxity. Also 4 of the patients who

had a C score (50-75%) in the triple hop test, had no laxity (Lachman's A). It remains unclear how patients with laxity clinically do functionally better and vice versa.

There was no association found between the Lachman's anterior laxity and the triple hop test using the chi-square test (χ^2 = 2.3528) with p-value of 0.672. There was moderate correlation seen between the triple hop test and the subjective function of the patient via the Pearson correlation analysis (r=0.59) with p value of 0.005. A strong correlation(r=o.668) with p value of 0.001 was found in the analysis between subjective function and Tegner activity score. Correlation between the IKDC subjective score and Tegner activity score also revealed a very strong correlation (r = o.762) with p value of 0.000 using the Pearson correlation analysis.

Assessment of knee function in terms of squatting, stair climbing, showed that none of the patients had significant difficulty with either squatting or stair climbing postoperatively. Post-operatively all had full range of movement at their knee joints and none of the patients had anterior knee pain or difficulty while kneeling down. 9 patients out of 21 complained of numbness/ altered sensation in the lateral aspect of leg probably due to injury to the infra patellar branch of saphenous nerve. Similar results of altered sensation due to injury to infra-patellar branch of saphenous nerve in 100% of patients has been reported by Howell[8].

Overall there has been a significant improvement in clinical and functional outcome following hamstring reconstruction following ACL injury.

Proprioception

Assessment of proprioception of the ACL deficient knees in our study included, the three different tests , angle reproduction test, kineasthesia (TDPM) test and the Balance Master test .The groups studied included the patients with ACL deficient knee, their unaffected contra lateral knee and the control knees of healthy subjects.

There were significant proprioceptive differences between the ACL deficient knees and that of the controls similar to the studies done by Barrett[35], Fremrey[36] Ozenci [41] and MacDonald [9]. This proprioceptive deficit in chronic ACL-deficient knees may be the result of a loss of passive restraint which causes stretching of capsular structures and a decreased response of capsular receptors. The disturbance of proprioception may also be a cause of increased joint laxity as well as a result of it.[36]

Among the three tests, the Kineasthesia(TDPM) did not show significant difference between the ACL deficient knees and that of the controls as already shown by Mc Donald[9] and G.Pap[42]Proprioceptive deficit difference cannot be concluded only on the basis of TDPM, as the other tests of proprioception – ie - angle reproduction test and the balance master test reveal significant differences.

Interestingly **Ozenci et al**[41] followed up the proprioception of four groups of patients (normal controls, with allograft ACL reconstruction, with auto graft ACL reconstruction and patients with ACL deficient knees.) using the TDPM and JPS There was a significant difference in proprioception between patients with injured ACL's and the other three groups in TDPM evaluation.

In our study, we found no significant difference in proprioception between the ACL deficient knee joint and that of the unaffected contra lateral knee joint. There was a loss in proprioception of both knees as compared to that of normal controls. The reason for the loss in the proprioception in the contra lateral knee could be because of cross representation of body parts in the brain . Similar findings have been seen in patients with cerebrovascular stroke, where strengthening of opposite limb increasing the muscle strength of the affected limb.

There are proprioceptive nerve endings present at the bone-tendon junction. Following an injury to the Anterior Cruciate Ligament injury, the proprioception is certainly affected, but the other receptors both static and dynamic at the capsule, tendons and collateral ligaments play a role in proprioception. Because of the laxity present at the knee, the knee becomes unstable and moves in a disorganized manner which is interpreted differently at the cortical level. By restoring mechanical stability by ACL reconstruction, these remaining receptors seem to recover and to compensate for the lack of mechanoreceptors in the

ACL, especially at the extreme ranges of movement. By restoring a more physiological joint movement, cortical interpretation is enhanced. Success after ligament reconstruction may not depend directly on the tightness or strength of the reconstruction, as was thought, but rather on the quality of recovery of proprioception.[35]

It has been suggested that muscle spindles play an important role in detection of movement.[53,54] Inhibition of the quadriceps muscle can contribute to the functional disability in ACL-deficient knees[55,56]and has to be considered in relation to the proprioceptive loss. Individual differences in the ability to compensate for loss of the ACL through input from muscle or tendon receptors could be responsible for these different findings.[9] Supraspinal processing of afferent signals may vary from person to person depending, for example, on their concentration.[57] Many intra-articular and extra-articular factors have an influence on the development and extent of the proprioceptive deficit associated with loss of the ACL.

The correlation of improvement in proprioception post-operatively along with patients satisfaction, clinical and functional outcome needs to studied in detail. The changes in proprioception of the contra lateral knee following ACL reconstruction also needs to be studied. The effect of time on the proprioceptive loss in both the affected , and the contra lateral knee also needs to be studied. A longer follow up in a larger cohort of patients could yield more

useful results.

Conclusions

A. Assessment of outcome of ACL Reconstructed Knees :

There is a significant improvement in clinical outcome of the patients who underwent ACL reconstruction using hamstring tendon as assessed by,

a. subjective outcome (IKDC subjective scores, Lysholm Score)
b. laxity (Lachman's, pivot shift tests in the IKDC objective scores.)
c. objective clinical outcome measures (IKDC Objective Score)
d. functional outcome (Lysholm, Tegner Activity Score, hop tests.)
e. Quality of life measurements (SF-36 health questionnaire.)

B. Proprioceptive study (pre-operative study)

1. There are significant proprioceptive deficits present in Anterior Cruciate Ligament deficient knees when compared to that of the controls, as assessed by the angle reproduction test and balance master test.

2. Significant Proprioceptive deficits were also found in the unaffected contra lateral knee joint, when compared to that of the controls.

3. The loss in proprioception of the ACL deficient knee joint and unaffected contra lateral knee joints of the same patient was similar. The difference between the two was not significant.

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Appendix

APPENDIX 1: IKDC SUBJECTIVE FORM

2000 IKDC SUBJECTIVE KNEE EVALUATION FORM

Your Full Name_____

Today's Date: _____/_____/_____ Date of Injury: _____/_____/_____

SYMPTOMS*:

*Grade symptoms at the highest activity level at which you think you could function without significant symptoms, even if you are not actually performing activities at this level.

1. What is the highest level of activity that you can perform without significant knee pain?

4❑Very strenuous activities like jumping or pivoting as in basketball or football
3❑Strenuous activities like heavy physical work, skiing or tennis
2❑Moderate activities like moderate physical work, running or jogging

1❑Light activities like walking, housework or yard work
0❑Unable to perform any of the above activities due to knee pain

2. During the past 4 weeks, or since your injury, how often have you had pain?

	10	9	8	7	6	5	4	3	2	1	0	
Never	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	Constant

3. If you have pain, how severe is it?

	10	9	8	7	6	5	4	3	2	1	0	
No pain	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	Worst pain Imaginable

4. During the past 4 weeks, or since your injury, how stiff or swollen was your knee?

4❑Not at all
3❑Mildly
2❑Moderately
1❑Very
0❑Extremely

5. What is the highest level of activity you can perform without significant swelling in your knee?

4❑Very strenuous activities like jumping or pivoting as in basketball or soccer
3❑Strenuous activities like heavy physical work, skiing or tennis
2❑Moderate activities like moderate physical work, running or jogging
1❑Light activities like walking, housework, or yard work
0❑Unable to perform any of the above activities due to knee swelling

6. During the past 4 weeks, or since your injury, did your knee lock or catch?

0❑Yes 1❑No

7. What is the highest level of activity you can perform without significant giving way in your knee?

4❑Very strenuous activities like jumping or pivoting as in basketball or soccer
3❑Strenuous activities like heavy physical work, skiing or tennis
2❑Moderate activities like moderate physical work, running or jogging
1❑Light activities like walking, housework or yard work
0❑Unable to perform any of the above activities due to giving way of the knee

SPORTS ACTIVITIES:

8. What is the highest level of activity you can participate in on a regular basis?

4❑Very strenuous activities like jumping or pivoting as in basketball or soccer
3❑Strenuous activities like heavy physical work, skiing or tennis
2❑Moderate activities like moderate physical work, running or jogging
1❑Light activities like walking, housework or yard work
0❑Unable to perform any of the above activities due to knee

9. How does your knee affect your ability to:

	Not difficult at all	Minimally difficult	Moderately difficult	Extremely difficult	Unable to do
Go up stairs	4❑	3❑	2❑	1❑	0❑
Go down stairs	.4❑	3❑	2❑	1❑	0❑
Kneel on the front of your knee	4❑	3❑	2❑	1❑	0❑
Squat	4❑	3❑	2❑	1❑	0❑

Sit with your knee bent	4❑	3❑	2❑	1❑	0❑
Rise from a chair	4❑	3❑	2❑	1❑	0❑
Run straight ahead	4❑	3❑	2❑	1❑	0❑
Jump and land on your involved leg	4❑	3❑	2❑	1❑	0❑
Stop and start quickly	4❑	3❑	2❑	1❑	0❑

FUNCTION:

10. How would you rate the function of your knee on a scale of 0 to 10 with 10 being normal, excellent function
and 0 being the inability to perform any of your usual daily activities which may include sports?

FUNCTION PRIOR TO YOUR KNEE INJURY:

Couldn't perform daily activities 0 ❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5 ❑ 6 ❑ 7 ❑ 8 ❑ 9 ❑ 10 ❑ No limitation of dailiy activities

CURRENT FUNCTION OF YOUR KNEE:

Cannot perform daily activities 0 ❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5 ❑ 6 ❑ 7 ❑ 8 ❑ 9 ❑ 10 ❑ No limitation of daily activities

APPENDIX 2 : IKDC OBJECTIVE FORM

KNEE HISTORY:

Patient Name _____

Involved Knee: ❑Right ❑Left

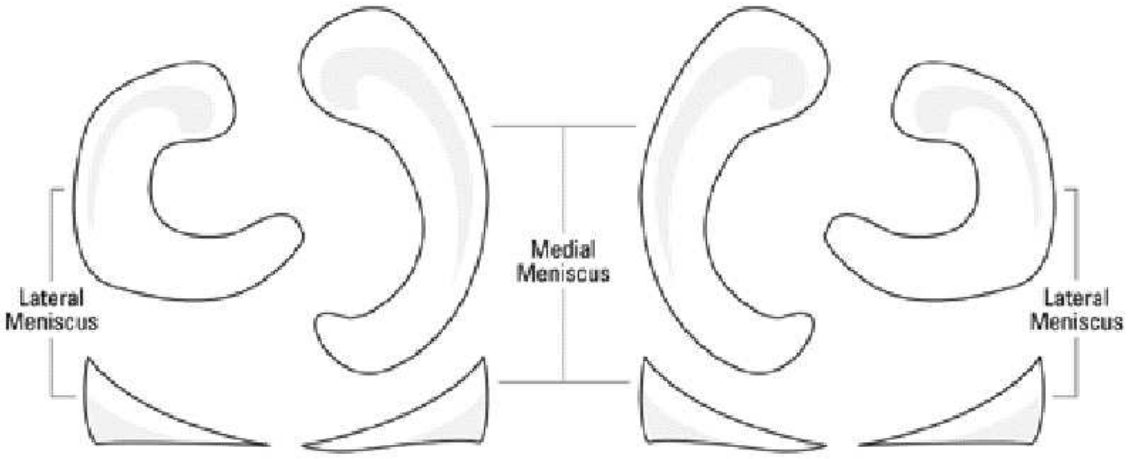
Chief Complaints: 1. Pain 2. Swelling 3. Instability 4. Locking.

Activity at Injury: ❑ADL ❑Sports ❑Traffic ❑Work

KNEE DOCUMENTATION:

MENISCUS STATUS:

RIGHT KNEE LEFT KNEE



Meniscus involved : Medial Lateral

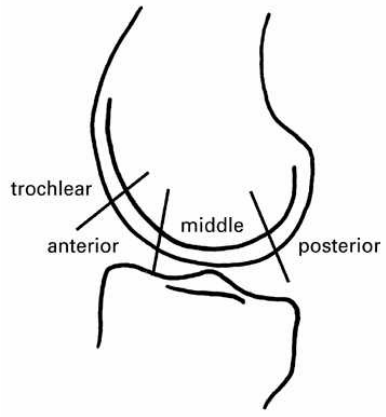
Site of Tear: anterior middle posterior

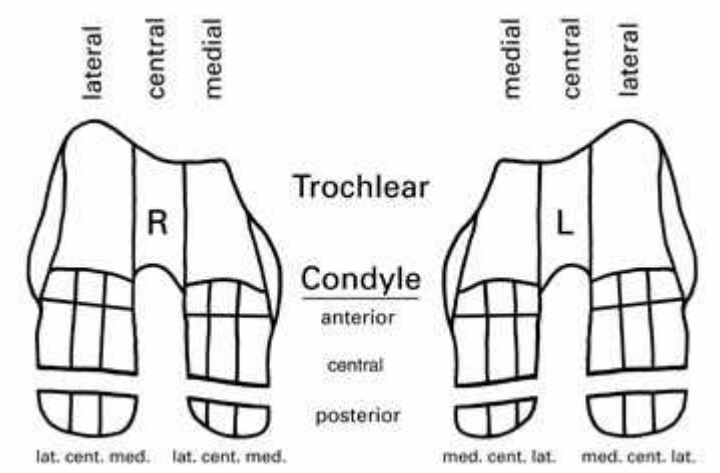
Postion of Tear: Inner 1/3rd middle 1/3rd Outer1/3rd

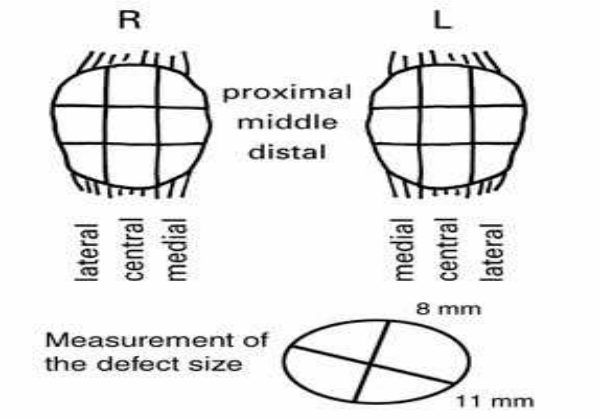
Surgery done:

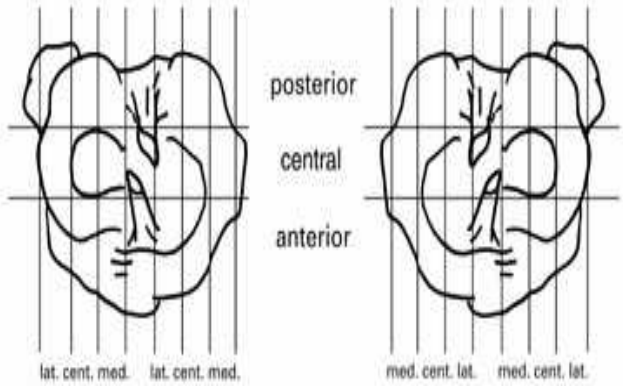
ARTICULAR CARTILAGE STATUS:

Document the size and location of articular cartilage defects on these figures according to the ICRS
mapping systemc.









KNEE SURGERY:

ACL RECONSTRUCTION**:**

Graft Used:

Semi-tendinosus tendon

ST along with Gracilis.

Bone-Patellar tendon-Bone.

Fixation Device:

Femur:

Interference screw
Endobutton

Tibia:

Interference screw
Fixation post.

IKDC KNEE EXAMINATION:

Patient Name:_____

Gender: F M

A**ge**:__

Generalized Laxity: TIGHT NORMAL LAX

Range of Motion (Ext/Flex):

Index Side: passive_____/_____/_____ active_____/_____/_____

Opposite Side: passive_____/_____/_____ active_____/_____/_____

GROUPS	ACTUAL MEASUREMENT	A NORMAL	B NEAR NORMAL	C ABNORMAL	D SEVERELY ABNORMAL	GROUP GRADE (A,B,C,D.)
Effusion		None	Mild	Moderate	Severe	

Lack of extension Lack of flexion	Actual extension - Actual flexion -	<3° 0 – 5°	3 – 5° 6 – 15°	6 – 10° 16 – 25°	>10° >25°	
Ligament Examination Lachman'stest Anterior Drawer's test Posterior Drawer's test Lateral joint opening Medial joint opening Pivot Shift test		 -1 to 2 mm firm 0 – 2mm 0 – 2mm 0 – 2mm 0 – 2mm Equal	 3 – 5mm firm 3 – 5mm 3 – 5mm 3 – 5mm 3 – 5mm +glide	 6 – 10mm soft 6 – 10mm 6 – 10mm 6 – 10mm 6 – 10mm ++clunk	 >10mm soft >10mm >10mm >10mm >10mm +++gross	
Functional Test One leg hop (% of opposite side) **Patellar pain on kneeling**	Affected leg – Unaffected leg -	>/=90% None (kneel >15secs without pain	89 – 76% Mild (can kneel <15secs	75 – 50% Moderate (can kneel for 5 secs	< 50% Severe (cannot kneel)	

3.APPENDIX; SF-36 HEALTH QUESTIONNAIRE:

HEALTH STATUS QUESTIONNAIRE (SF-36)

This survey asks for your vies about your health. Please answer every question by circling the appropriate number: 1,2,3, etc. If you are unsure about how to

answer a question, please give it the best answer you can and make a comment in the left margin, or on the back.

1. In general, would you say your health is:
Excellent 1
Very good 2
Good 3
Fair 4
Poor 5

2. Compared to one year ago, how would you rate your health in general now?
Much better now than 1 year ago 1
Somewhat better now than 1 year ago 2
About the same 3
Somewhat worse now than 1 year ago 4
Much worse now than 1 year ago 5

3. The following questions are about activities you might do during a typical day.
Yes, Limited a Lot Yes, Limited a Little No, Not Limited at All

a. Vigorous activities, such as running, lifting heavy 1 2 3
objects, participating in strenuous sports

b. Moderate activities, such as moving a table, pushing 1 2 3
a vacuum cleaner, bowling, or playing golf

c. Lifting or carrying groceries 1 2 3
d. Climbing several flights of stairs 1 2 3

e. Climbing one flight of stairs 1 2 3

f. Bending, kneeling, or stooping 1 2 3

g. Walking more than 1 mile 1 2 3

h. Walking several blocks 1 2 3

i. Walking one block 1 2 3

j. Bathing and dressing yourself 1 2 3

4. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

Yes No

a. Cut down on the amount of time you spent on work or other activities 1 2

b. Accomplished less than you would like 1 2

c. Were limited in the kind of work or other activities 1 2

d. Had difficulty performing the work or other activities (e.g., it took extra effort) 1 2

5. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (e.g., feeling depressed or anxious)?

Yes No

a. Cut down on the amount of time you spent on work or other activities 1 2

b. Accomplished less than you would like 1 2

c. Didn't do work or other activities as carefully as usual 1 2

6. During the past 4 weeks, to what extent have your physical health or emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?

Not at all 1
Slightly 2
Moderately 3
Quite a bit 4
Extremely 5

7. How much body pain have you had during the past 4 weeks?

None 1
Very mild 2
Mild 3
Moderate 4
Severe 5
Very severe 6

8. During the past 4 weeks, how much did pain interfere with your normal work (including work both outside the home and housework)?

Not at all 1
A little 2
Moderately 3
Quite a bit 4
Extremely 5

9. These questions are about how you feel and how things have been with you during the past month. For each question, please indicate the one answer that comes closest to the way you have been feeling. How much of the time during the past month All of Most of A Good Bit of Some of A Little of None of
the Time the Time the Time the Time the Time the Time

a. Did you feel full of pep? 1 2 3 4 5 6

b. Have you been a very nervous person? 1 2 3 4 5 6

c. Have you felt so down in the dumps 1 2 3 4 5 6
nothing could cheer you up?

d. Have you felt calm and peaceful? 1 2 3 4 5 6

e. Did you have a lot of energy? 1 2 3 4 5 6

f. Have you felt downhearted and blue? 1 2 3 4 5 6

g. Did you feel worn out? 1 2 3 4 5 6

h. Have you been a happy person? 1 2 3 4 5 6

i. Did you feel tired/ 1 2 3 4 5 6

j. Has your health limited your social activities 1 2 3 4 5 6
(like visiting your friends or close relatives)?

10. Please choose the answer that best describes how true or false each of the following statements is for you.
Definitely Mostly Mostly Definitely
True True Not Sure False False

a. I seem to get sick a little easier than other people 1 2 3 4 5

b. I am as healthy as anybody I know 1 2 3 4 5

c. I expect my health to get worse 1 2 3 4 5

d. My health is excellent 1 2 3 4 5

11. Please answer YES or NO for each question by circling 1 or 2 on each line.
Yes No

a. In the past year, have you had 2 weeks or more during which you felt sad, blue, or depressed; 1 2
or when you lost all interest or pleasure in things you usually care about or enjoyed?

b. Have you had 2 years or more in your life when you felt depressed or sad most days, 1 2
even if you felt okay sometimes?

c. Have you felt depressed or sad much of the time in the past year? 1 2

APPENDIX 4 : LYSHOLM SCORE:

LYSHOLM KNEE SCORE

Please ***CIRCLE the LETTER*** of the response that best describes the function of your knee at this time.

HOW MUCH DO YOU NOTICE YOURSELF *LIMPING*?
A. NONE 5
B. SLIGHT OR PERIODIC 3
C. SEVERE OR CONSTANT 0

DO YOU REQUIRE *CRUTCH SUPPORT*?
A. NONE 5
B. CANE OR CRUTCH 2
C. WEIGHT BEARING IMPOSSIBLE 0

DOES YOUR KNEE *LOCK-UP* ON YOU (Locking is when you knee gets stuck in a bent position and you cannot straighten it without moving it around)?
A. NO LOCKING OR CATCHING SENSATIONS 15
B. CATCHING SENSATION BUT NO LOCKING 10
C. LOCKING OCCASIONALLY 6
D. LOCKING FREQUENTLY 2
E. LOCKED NOW 0

DESCRIBE YOU KNEE FUNCTION WITH *STAIRCLIMBING*:
A. NO PROBLEMS 10
B. SLIGHTLY IMPAIRED 6
C. ONE STEP AT A TIME 2
D. IMPOSSIBLE 0

DESCRIBE YOUR KNEE FUNCTION WITH *SQUATTING*:
A. NO PROBLEMS 5
B. SLIGHTLY IMPAIRED 4
C. NOT BEYOND 90 DEGREES 2
D. IMPOSSIBLE 0

HAVE YOU RETURNED TO YOUR PRE-INJURY LEVEL OF SPORTS ACTIVITY?
A. YES
B. NO WHY? _____

Lysholm Knee Score Cont.)

DESCRIBE ANY KNEE *INSTABILITY* YOU HAVE: (LYSHOLM)

A. NEVER GIVES WAY (25)
B. RARELY GIVES WAY DURING ATHLETICS OR OTHER SEVERE EXERTION (20)
C. FREQUENTLY GIVES WAY DURING ATHLETICS OR OTHER SEVERE EXERTION OR INCAPABLE OF PARTICIPATION (15)
D. OCCASIONALLY GIVES WAY IN DAILY ACTIVITIES (10)
E. OFTEN GIVES WAY IN DAILY ACTIVITIES (5)
F. GIVERS WAY WITH EVERY STEP (0)

HOW MUCH *PAIN* DO YOU HAVE?

A. NONE (25)
B. INCONSTANT AND SLIGHT DURING SEVERE EXERTION (20)
C. MARKED DURING SEVERE EXERTION (15)
D. MARKED ON OR AFTER WALKING MORE THAN 2 KM (10)
E. MARKED ON OR AFTER WALKING LESS THAN 2 KM (5)
F. CONSTANT (0)

HOW MUCH DO YOU NOTICE YOUR KNEE *SWELLING*?

A. NONE (10)
B. ON SEVERE EXERTION (6)
C. ON ORDINARY EXERTION (2)
D. CONSTANT (0)

TOTAL LYSHOLM SCORE: _____ (100)

APPENDIX 5: TEGNER ACTIVITY SCORE:

Tegner Activity Score

Circle the number which best corresponds to your current activity level. **Circle only one number**.

10. Competitive sports
Soccer-national and international elite

9. Competitive sports
Soccer, lower divisions
Ice hockey, Wrestling, Gymnastics

8. Competitive sports
Bandy, Squash or badminton
Athletics (jumping, etc.)
Downhill skiing

7. Competitive sports
Tennis, Handball
Athletics (running)
Motorcross, speedway
Basketball

Recreational sports
Soccer, Squash
Bandy and ice hockey
Athletics (jumping)
Cross-country track findings both recreational and competitive

6. Recreational sports
Tennis and badminton
Handball
Basketball
Downhill skiing
Jogging, at least five times per week

5. Work – heavy labor (e.g., building, forestry)
Competitive sports
Cycling
Cross-country skiing
Recreational sports
Jogging on uneven ground at least twice weekly

4. Work – Moderately heavy labor (e.g., truck driving, heavy domestic work)

Recreational sports
Cycling
Cross-country skiing
Jogging on even ground at least twice weekly

3. Work – Light labor (e.g., nursing)
Competitive and recreational sports - swimming

2. Work – Light labor
Walking on uneven ground possible but impossible to walk in forest

1. Work – Sedentary work
Walking on even ground possible

0. Sick leave or disability pension because of knee problems

APPENDIX 6 : ACL REHABILITATION PROTOCOL

ACL REHABILITATION

Goals of ACL surgery and rehabilitation :
- Restore normal joint anatomy.
- Provide static and dynamic stability.
- Return to work and sport as quickly as possible.

Precautions and Considerations:
- *Kinematics of knee movement*: Between 10 degrees and 45 degrees flexion, quadriceps contraction causes greatest strain on the ACL.
- *Graft Protection*: The new graft undergoes physiological changes as fibroblast activity changes the graft's morphology to become more ligamentous. The graft is weakest between 6 and 12 weeks post-operatively. Therefore, BE CAREFUL DURING THIS PERIOD.
- *Closed chain exercises*: Rather than open chain exercises are utilised and designed to minimise load on the ACL graft (see appendix).
- *Loss of ACL mechanoreceptors*: Therefore, there must be a large emphasis on proprioceptive work.

Open versus Closed Chain Exercise
Closed kinetic chain exercises are performed with the foot placed on a surface (e.g. floor, step, pedal) and the entire limb is bearing a load and compressed.
In open chain exercises (e.g. leg extensions) a relatively larger shear stress is applied to the joint.
Closed chain exercises performed near full extension have less patellofemoral joint forces. Co-activation of quadriceps and hamstrings help to reduce anterior shear thereby decrease the strain on the ACL.
The closed kinetic chain exercise places functional stresses on the joint and the extremity in ways that are similar to normal weight bearing activities.
The joint compression that occurs when the extremity is loaded by body weight provides inherent joint stability and allows more strenuous strengthening work outs without the degree of shearing forces that occur with conventional open kinetic exercises. (Shelbourne & Nitz, 1990).

Knee Braces
There is still no research which shows that braces can control knee rotation.
If the patient's knee is stable and they have completed a comprehensive rehabilitation programme they do not need to wear any type of brace for return to sport

Meniscal Injuries
In case of an associated meniscal surgery, delay weight bearing for about 4-6 weeks – to allow for meniscal healing.

Day 1 to 2 weeks

Goals:

- ROM 0-90°
- Adequate quadriceps contraction
- Control inflammation, effusion
- 50% weight bearing with 2 crutches

Range of motion

- ROM (passive, 0-90°)
- Patella mobilization
- Hamstring, gastroc-soleus stretches
- Prone extension with 3-5-pound weight if knee is not coming into full extension

Strengthening

- Active static quadriceps isometrics (in full extension)
- Knee flexion (active, 0-90°) in supine position and sitting
- Knee extension - sitting (active-assisted. 90-45°)

Balance training

- Weight shift side/side and forward/back – with crutches

Modalities

- Electrical muscle stimulation
- Biofeedback
- Cryotherapy if needed

3-4 weeks

Goals:

- Increase ROM
- Increase weight bearing
- Increase hamstring and quads control
- Progress out of brace

Range of motion

- 0 - 120 degrees ROM should be aimed for by 4 weeks
- Continue Patella mobilization,
- Hamstring, gastroc-soleus stretches, and
- Prone extension with 3-5-pound weight if knee is not coming into full extension

Strengthening

- Straight leg raises
- Isometric training: multi-angle - Static co-contraction of hamstring and quadriceps at 0 degrees, 60 degrees and 90 degrees continues. Do these with the tibia externally rotated (both legs together)
- Hamstring curls - standing (active –, 0-90°)
- Knee extension - sitting (active, 90-30°)
- Closed-chain
    - 45 degree Wall sits
    - Mini-squats

Balance training

- Weight shift side/side and forward/back
- Cup walking

Aerobics

- Stationary bike

NOTE

- Brace is worn up to week 4. Patients with lax ligaments (i.e. hyperelasticity) will be immobilised for 6 weeks. Patient can come out of the brace for physiotherapy. Patient may remove brace for sleeping.

- Progress to full weight bearing once quads control is good and near to full extension.

5-6 weeks

Goal

- ROM 0-135°
- Full weight bearing, normal gait
- Muscle endurance

Range of motion

- 0 – 135 degrees ROM
- Full extension expected.

Strengthening

- Straight leg raises with weights at the thigh (not to exceed 10% of body weight) - slowly increase reps
- Isometric training: multi-angle (90, 60, 30°)
- Heel raise/toe raise (both legs together)
- Hamstring curls - standing (active, 0-90°) – with mild resistance
- Closed-chain
  - Wall sits – slowly increase
  - One third mini-squats

Balance training

- wobble board -2 legged
- Lateral step-ups: 2-4”
- Single leg stance (level surface)

Aerobic conditioning *(take patellofemoral precautions)*

- Stationary bicycling
- Water walking

6-12 weeks

Goals

- Increase strength and endurance

Strengthening

- Straight leg raises – with weights at the thigh
- Heel raise/toe raise
- Hamstring curls with weights (active, 0-90°)
- NB. Still no open chain resisted leg extensions.
- Closed-chain
  - Wall sits
  - half squats

Balance training

- Single limb stance
- Balance board -2 legged

Walking/Steps

- Lateral step-ups: 2-4”
- Walking backward

3 mths – 6 mths

Goals

- Increase strength and endurance

Strengthening

- Heel raise/toe raise
- Hamstring curls with weights (active, 0-90°)
- NB. Still no open chain resisted leg extensions.
- Closed-chain
  - Wall sits
  - half squats with weights

Balance Training and running

- Proprioceptive work on mini-tramp such as landing on affected leg and hopping.
- Agility work, e.g. Catching a ball, sideways running, two leg jumping, cutting – figure of 8, skipping rope etc.
- Step work on progressively higher steps
- cycling
- backward run
- jogging

>6 months

Goal:

- Return to sport

Activity:

- Can begin open chain leg extensions with weights for
- Sport specific skills and cardiovascular fitness must be excellent before return to competition.

ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION: QUADRUPLED HAMSTRING TENDON GRAFT - A PROSPECTIVE FOLLOW-UP STUDY

&

A STUDY OF THE PROPRIOCEPTION IN THE ACL DEFICIENT KNEE

Introduction: The use of autogenous hamstring tendon as a graft source for Anterior Cruciate Ligament (ACL) reconstruction is gaining popularity in account of its low harvest morbidity and excellent bio-mechanical graft properties coupled with improved fixation of the soft tissue grafts.In this study, we audited the clinical and functional outcome of patients who had their ACL reconstructed arthroscopically using the hamstring tendon graft. Many studies also suggest that proprioceptive functions of the knee are very important for the integrity and stability of the joint. We studied the changes in proprioception that occurred in the ACL deficient knee, and the contra lateral knee joint following the injury.

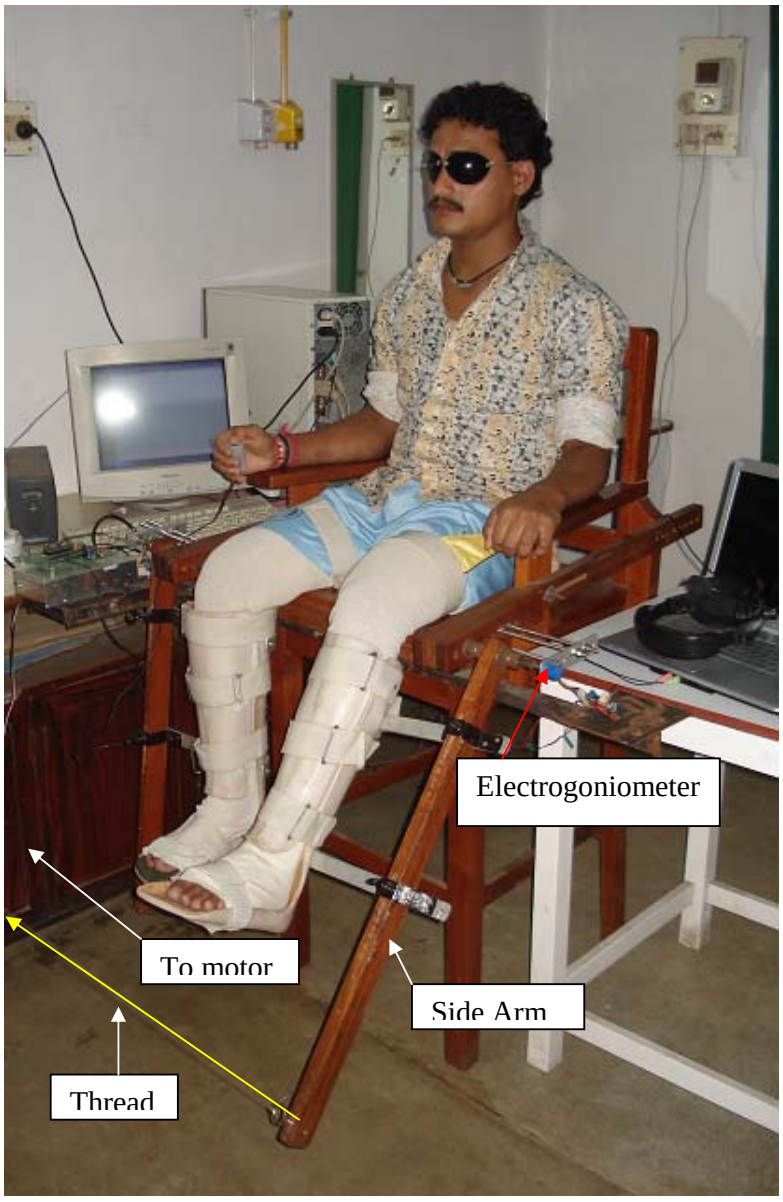
Methodology: In 21 patients with ACL deficient knees, the International Knee Documentation Committee (IKDC) - subjective and objective evaluation system, Lysholm score, Tegner Activity Score, Single and Triple Hop tests , and SF-36 health questionnaire were used as assessment criteria - both before surgery, and 1 year post-operatively. Proprioception was evaluated using an electrogoniometer – both in terms of joint position sense(active and passive reproduction tests) and threshold to detect passive motion (TDPM), and with the balance master. These parameters were assessed in the affected knee, the contra-lateral knee joint and in age-matched control groups.

Results: The IKDC subjective scores improved from 54.96 to 80.57($p<0.001$), Lysholm Scores from 54.5 to 89.8($p<0.001$),

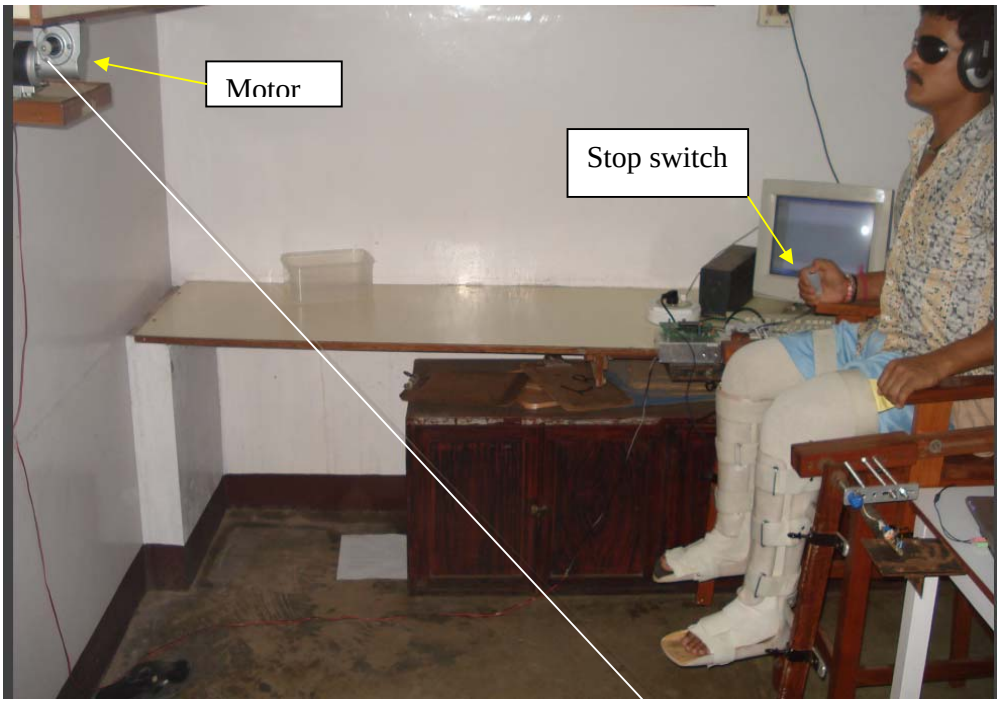
Tegner Activity score from 2.3 to 5.52($p < 0.001$), and the SF-36 physical scores from 32.62-37.14,($p = 0.007$) following surgery. All patients had more than 5mm of anterior translation or more on Lachman's test preoperatively, but all had less than 5mm postoperatively. While 95% of the patients had occasional to frequent instability preoperatively, 90% had no significant problems postoperatively. In the hop tests, only 19% of the patients were able to triple hop >75% of their unaffected limb. Post-operatively 76% were able to do >75% in the triple hop test.

The results of the differences in proprioception of the ACL deficient knee, the contra lateral knee, and control knee joints are also presented. 25 patients and controls were enrolled for this study. There were significant proprioceptive deficits present in both the ACL deficient knees and the contra lateral 'normal' knees when compared to that of the controls, as assessed by the angle reproduction test and balance master test. The loss in proprioception of the ACL deficient knee joint and unaffected contra lateral knee joints of the same patient was similar. The Threshold to detection of passive movement (TDPM) did not show significant differences between the ACL deficient knee, the contra lateral knee, and the control knees.

Conclusion: Patients who had their ACLs reconstructed using the hamstring tendon had significant improvements in their clinical and functional scores postoperatively. There was a significant loss of proprioception in both the ACL deficient knee and the contra lateral 'normal' knee as compared to controls. Further studies are required on the effect of the surgery on proprioception of the joint following ACL reconstruction.



Picture of the special chair with its attachments



Picture of the chair connected to the motor

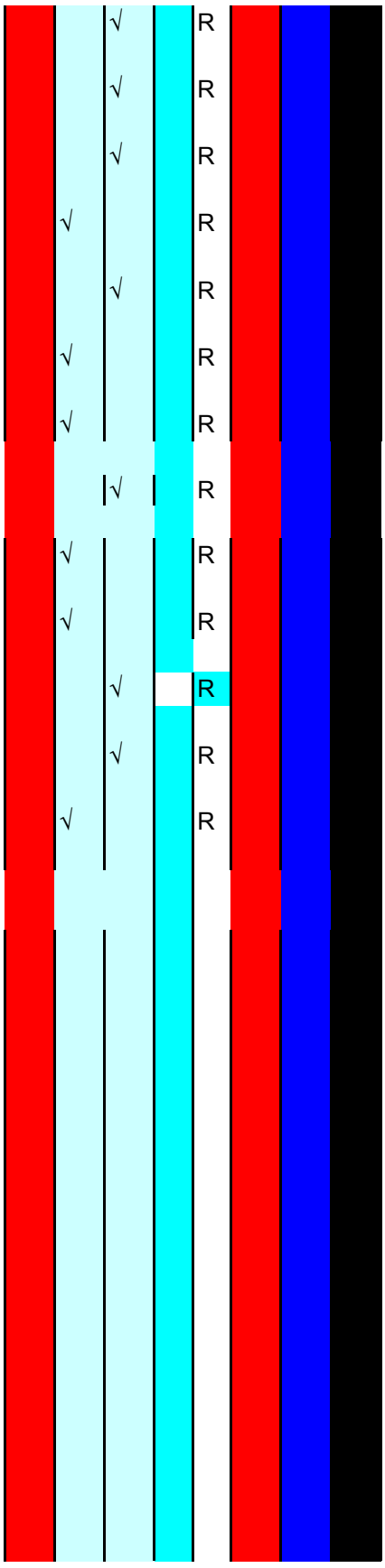
The Balance Master

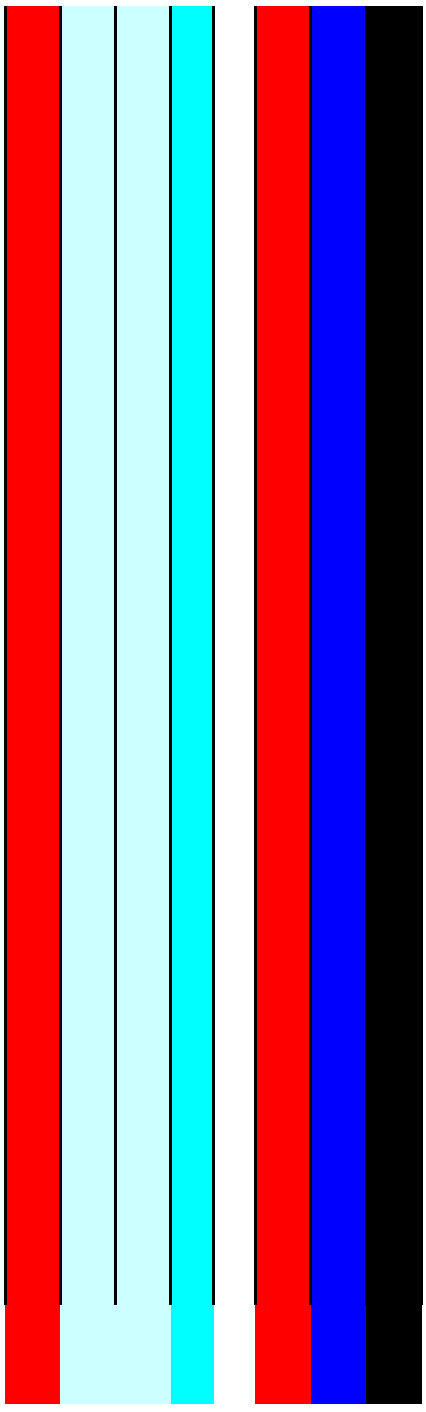
No.	Name	Hospital N	Date	SEX	ACT	AGE	Time si	GROUP	HAMS	B-PT-B	INDEX KNEE JOINT		JOINT POSITION SENSE	30 degrees	RIGHT KNEE JOINT	Passive P
1	MITHUN KUMAR	254026D	18.06.2008	M	s	17	0.2		√			L				
2	ABARNA		17.06.2008	F	S	26	2			√		L				
3	JHINTU GHOSH		03.07.2008	M	s	27	3		√			L				
4	RAJIB ACHARYA	269043D	04.07.2008	M	S	23	2		√			L				
5	SUBRATA BISWAS	266317D	10.07.2008	M	S	32	0.8			√		L				
6	SUDIP CHAKRABOI	274887D	15.07.2008	M	S	19	0.9		√			L				
7	RAJESH KUMAR	236874D	18.07.2008	M	A	20	0.4		√			L				
8	SAMBASIVAM	501611B	22.07.2008	M	A	30	4			√		L				
9	MADHUSUDHAN	277700D	22.07.2008	M	fall	24	1.0		√			L				
10	RAKESH KUMAR SI	252157D	22.07.2008	M	dan	24	0.7			√		L				
11	BIKRAM BAOURI	277216D	23.07.2008	M	S	24	0.7			√		L				
12	SUBRATA DAS	280962D	25.07.2008	M	fall	35	0.4		√			L				

FINAL

1	LEO FERNANDEZ	722626	03.07.2008	M	S	36	5			√		R
2	PRADIP DUTTA	253126D	03.07.2008	M	S	50	5			√		R
3	MAJUD KARIM SARKAR		04.07.2008	M	S	18	1			√		R
4	DEBASHISH DEY	267240D	04.07.2008	M	S	29	4		√			R
5	RAJENDRAN	262228D	08.07.2008	M	S	37	2			√		R
6	PARTHA SARATH	272433D	11.07.2008	M	S	23	7		√			R
7	NARAYANAN	242316D	11.07.2008	M	A	37	5		√			R
8	TONMOY BISWAS	292011D	14.07.2008	M	FAL	24	3			√		R
9	SANJAY SONUWAL	274058D	15.07.2008	M	S	22	3		√			R
10	DR. JOE VARGHES	428453C	18.07.2008	M	S	25	2		√			R
11	KISHANU CHAKRAI	202298D	19.07.2008	M	S	21	0.2			√		R
12	VIJAY .M.	457742C	19.07.2008	M	A	31	3			√		R
13	JAY DEV MANNA	279194D	22.07.2008	M	A	38	6		√			R
						28	2.45					

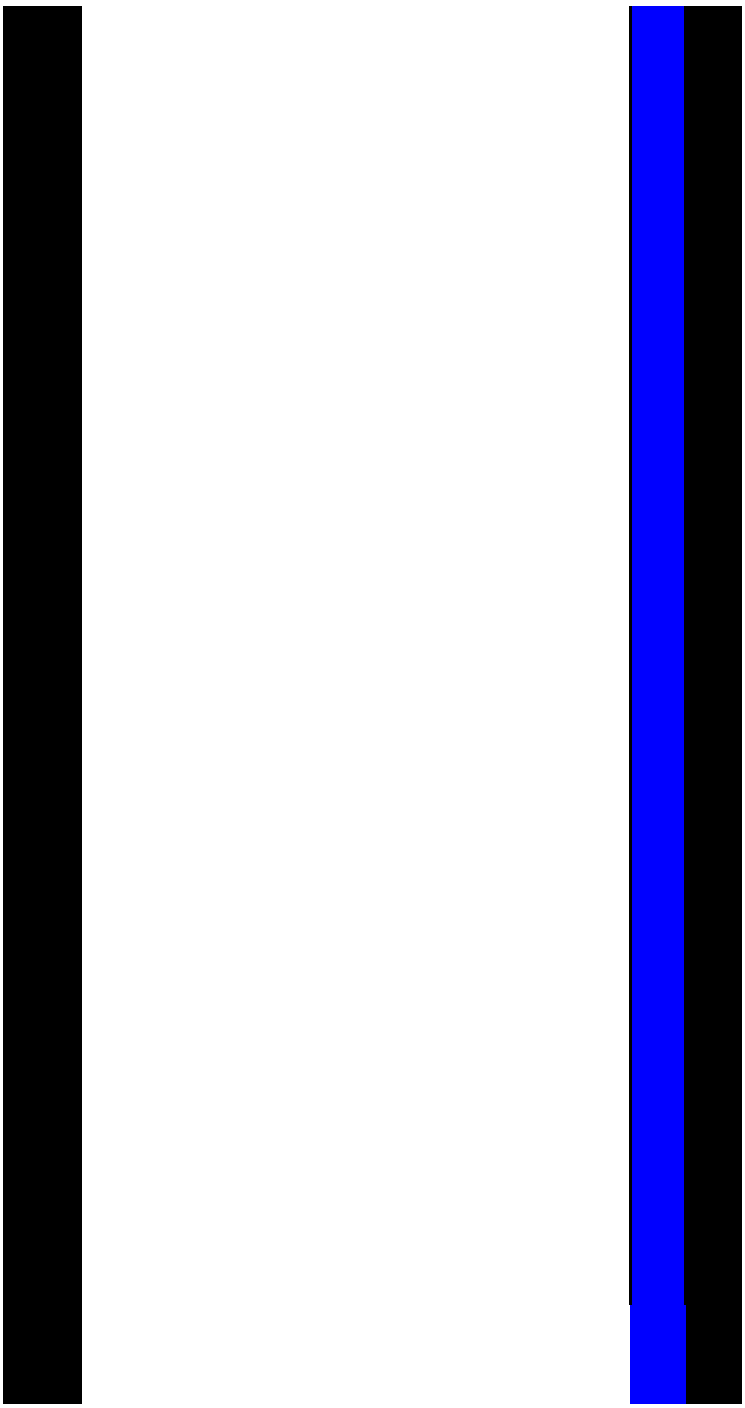
FINAL





Reproduction Angle				Active Reproduction Angle				LEFT KNEE JOINT	Passive Reproduction Angle				Active Reproduction Angle				45 degrees	RIGHT KNE
22	30.2	25.6		26	26.6	29			27	30	36		28.6	31.5	28			
8.2	0.2	4.4	4.267	4	3.4	1.4	2.9		2.7	0	6	3	1.4	1.5	2.2	1.7		
25	24.8	28							32	29	27							
5	5.2	1.8	4				4		2.1	0.9	3	2.0				2		
29	36.3	32		29.8	30.1	29			26	32	30		36	40	41			
1.2	6.3	1.5	3	0.2	0.1	1.4	0.6		4	2	0	2	6	10	11	9		
39	36.2	33		35.8	34.5	46			33	32	23		43	36.5	49.1			
9	6.2	2.5	5.9	5.8	4.5	16	8.9		3	2	7.2	3.9	13	6.5	19.1	##		
34	31.5	31.8		34	34.2	34			31	29	33		27.6	28.1	35.9			
3.8	1.5	1.8	2.367	4	4.2	4	4		1	1	3	1.67	2.4	1.9	5.9	3.4		
29	29.4	31		33.3	32.1	30			27	32	30		30.2	28.9	30.1			
1.1	0.6	1	0.9	3.3	2.1	0.1	1.8		2.6	2	0.3	1.53	0.2	1.1	0.1	0.5		
30	30.2	37.3		31.7	33.3	34			27	33	28		33.2	35.2	34.4			
0.4	0.2	7.3	2.633	1.7	3.3	4.4	3.1		2.6	3	2.1	2.7	3.2	5.2	4.4	4.3		
26	32.9	39.3		30.2	32.4	34			28	32	33		28	28.2	30.7			
4	2.9	9.3	5.4	0.2	2.4	4.3	2.3		1.9	2	2.6	2.1	2	1.8	0.7	1.5		
27	24	24.6		24.8	25	29			28	31	24		31.6	31.7	31.6			
2.7	6	5.6	4.767	5.2	5.2	1.1	3.8		1.9	1	5.8	2.9	1.6	1.7	1.6	1.6		
31	30.3	28.7		26	26.2	29			26	30	37		34.6	36	38.8			
0.5	0.3	1.3	0.7	4	3.8	1.2	3		4.5	0	7.2	3.9	4.6	6	8.8	6.5		
29	35.9	36.2		34.3	32.2	29			32	33	38		31.1	36.3	34.5			
0.7	5.9	6.2	4.267	4.3	2.2	0.6	2.4		1.6	3	7.5	4.13	1.1	6.3	4.5	4.0		
30	33	26		35.7	34.6	34			28	27	27		27	33.4	36.5			
0.3	3	4	2.433	5.7	4.6	4.4	4.9		2.5	3	2.7	2.77	3	3.4	6.5	4.3		
			3.386				3.5					2.71				4.3		
			1.659				2.1					0.91				3.6		

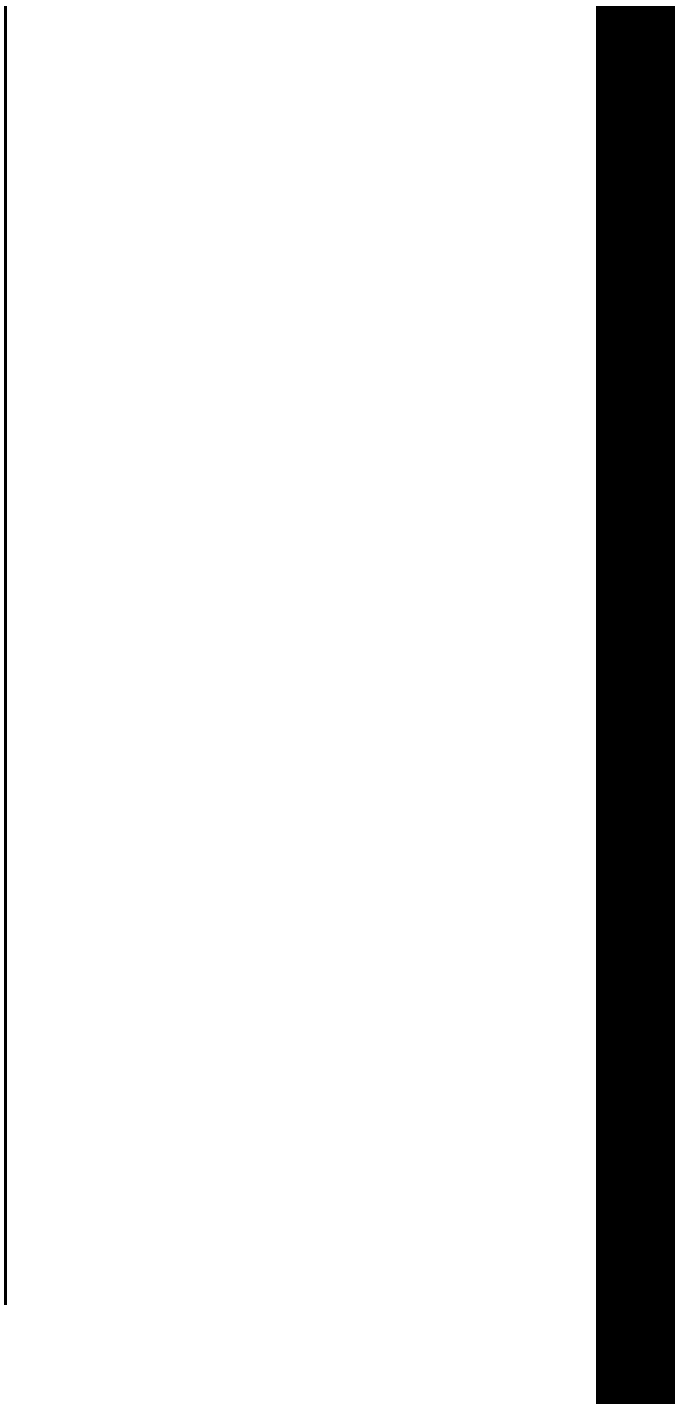
32	34	31		38.5	41.3	45		29	31	27		33.8	36.2	32.9	
1.6	4	1	2.2	8.5	11.3	15	12	1.4	1	2.6	##	3.8	6.2	2.9	4
32	39.8	39		42.5	37.3	37		37	36	36		33	33.1	34	
1.7	9.8	8.6	6.7	12.5	7.3	7.1	9	6.6	6	5.7	6.23	3	3.1	4	3.37
26	29.7	29		35.9	35.8	37		28	37	28		35.3	40.4	38	
3.7	0.3	1	1.67	5.9	5.8	7.4	6.4	7	6,5	2.4	4.7	5.3	10.4	8.2	7.97
27	33.8	35		33.1	39	28		32	40	38		22.5	31.9	28.4	
2.6	3.8	4.5	3.633	3.1	9	2.1	4.7	1.7	10	7.7	6.4	7.5	1.9	1.6	3.67
29	26.8	29		35.7	33.3	35.2		27	25	27		31.5	32.6	30.9	
1.2	3.2	1.2	1.87	5.7	3.3	5.2	4.73	3	5	3.2	3.87	1.5	2.6	0.9	1.67
25	31.5	34		32	33	39		31	33	33		33.2	33.2	34.1	
5.1	1.5	4	3.533	2	3	9	4.7	1	3	3	2.3	3.2	3.2	4.1	3.5
28	30.5	33		28.8	31.7	40		30	35	33		37.8	38	30.3	
2.5	0.5	3.3	2.1	1.2	1.7	10	4.3	0	5	3	##	7.8	8	0.3	5
35	33.5	38		27.7	27	26		30	32	34		30.2	32.1	32	
4.7	3.5	7.8	5.333	2.3	3.2	4.4	3.3	0.2	2	3.9	2	0.2	2.1	2	1
30	33	33		35.8	39.3	37		31	26	36		35.7	36.5	37	
0.1	3	3.2	2.1	5.8	9.3	7.2	7.4	1.3	4	6.4	##	5.7	6.5	6.5	##
23	31.9	35		40	40.7	40		27	33	32		33.5	34.4	35	
7.5	1.9	4.5	4.633	10	10.7	10	10	2.6	3	1.6	##	3.5	4.4	5.4	##
31	30.9	30		28.8	30.2	31		29	32	32		30.2	31.6	30	
0.8	0.9	0.2	0.633	1.2	0.2	0.7	0.7	1.2	2	2.4	##	0.2	1.6	0.2	1
30	35.5	38		28.9	29.1	30		30	26	33		31.7	33.2	36	
0	5.5	7.8	4.433	1.1	0.9	0.2	0.7	0.4	4	3	##	1.7	3.3	6.4	4
23	25.4	23		28.4	32	31		32	26	33		24.9	28.5	27	
6.8	4.6	7.1	6.167	1.6	1.6	0.8	1.3	2	4	3	3	5.1	1.5	2.9	3
			3.462				5.3				##				##
			1.887				3.5				##				2



KNEE JOINT Passive Reproduction Angle				Active Reproduction Angle			
47	29	37.3		40	38.1	40	
2.1	12	7.7	7.1	5	6.9	5	5.63
40	39.4	40					
4.9	5.6	4.9	5.1				5.13
47	51	50		50	42.5	46	
2.2	5.6	5.4	4.4	5	2.5	0.6	2.7
51	44.5	46		56.4	54	54.2	
6.4	0.5	0.6	2.5	11.4	9.4	9.2	10
44	43.6	49.3		45	46.9	46	
1.2	1.4	0.7	1.1	0.2	1.9	1.1	1.07
37	42.3	47.2		46	44.9	45	
7.6	2.7	2.2	4.2	1	0.1	0.2	0.43
42	41.5	45.7		46	46.7	47	
3.2	3.5	0.7	2.5	0.6	1.7	2	1.43
45	47	51.1		44	39.1	43	
0.5	2	6.1	2.9	1.5	5.9	1.6	3
43	37.5	39.3		48	45.6	45	
2	7.5	5.7	5.1	3.4	0.6	0.4	1.47
46	39.8	42.9		42	48.5	47	
0.7	5.2	2.1	2.7	2.8	3.5	2	2.77
46	48	50.3		47	43.3	47	
1.3	3	5.3	3.2	2.1	1.7	2.3	2.03
45	44.7	46.6		43	44.7	46	
0.4	0.3	1.6	0.8	2.1	0.3	0.9	1.1
			3.5				3.06
			1.8				2.7

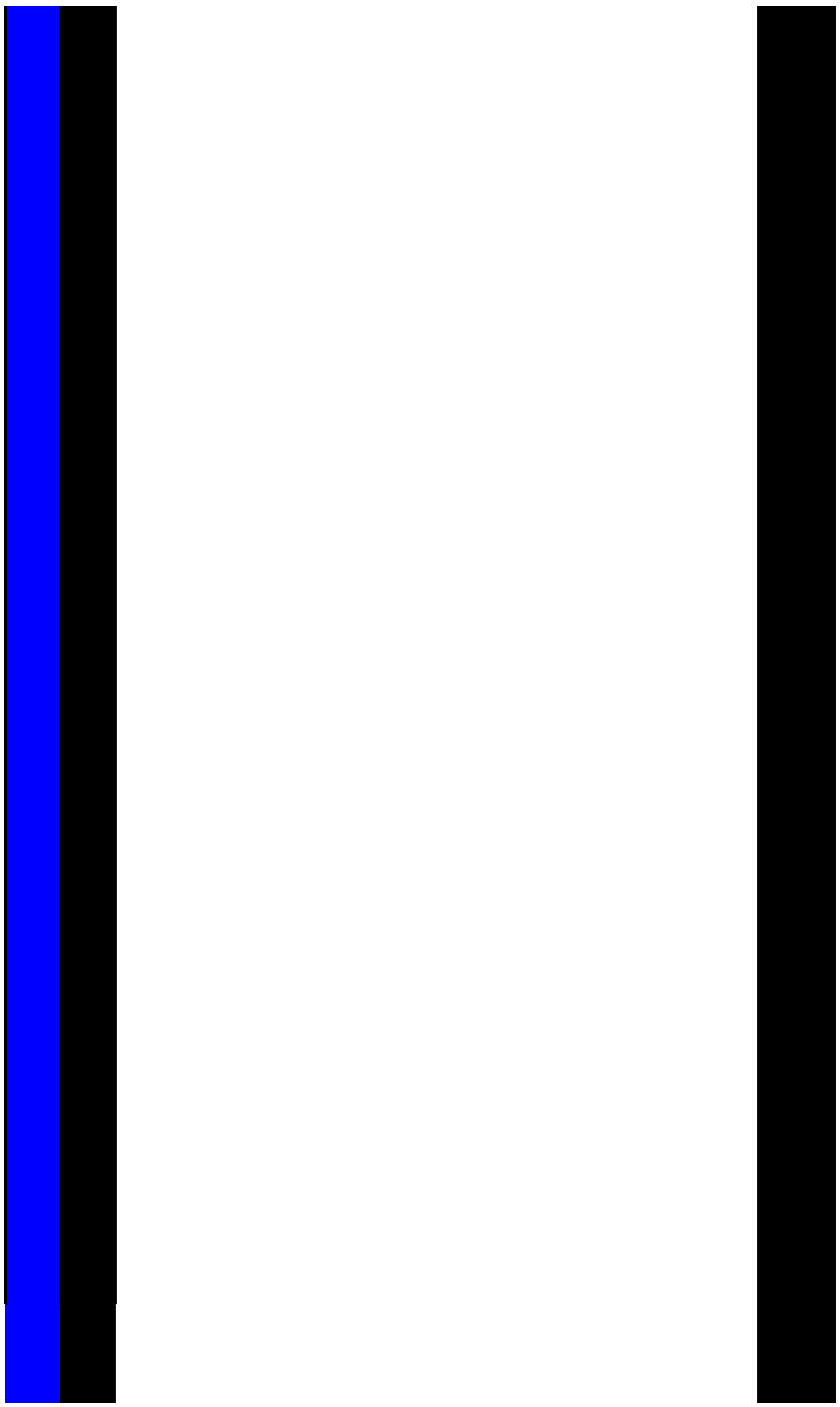
LEFT KNEE JOINT Passive Reproduction Angle				Active Reproduction Angle			
47	39	42.6		43	48.5	48.6	
2.2	7	2.4	3.7	1.8	3.5	3.6	3.0
39	41	41					
6.9	4	4.3	5.2				5.2
39	49	51		52	55.4	55.1	
6	4	5.4	5.0	7	10.4	10.1	9.2
49	42	45.8		56	57.6	55.5	
3.6	3	0.8	2.5	11	12.6	10.5	11.33
44	40	47		48	51.3	40.7	
0.6	5	2	2.5	3	6.3	4.3	4.53
39	44	43.5		47	50.5	51	
6.3	1	1.5	2.9	2.1	5.5	6	4.53
46	44	45.6		49	51.3	49.9	
1.4	1	0.6	0.9	3.6	6.3	4.9	4.93
53	38	42.9		44	45.8	43.5	
6.9	6	2.1	4.9	1.5	0.8	1.5	1.27
47	41	36.9		50	54.4	48.5	
1.5	4	8.1	4.6	5.4	9.4	3.5	6.10
49	42	48.6		46	50.8	52.8	
3.6	3	3.6	3.3	1.2	5.8	7.8	4.93
51	52	49.3		50	49.9	49.9	
5.5	7	4.3	5.6	5	4.9	4.9	4.93
43	39	45		48	47.8	49.1	
2	6	0	2.6	3.1	2.8	4.1	3.33
			3.6				5.27
			1.4				2.68

50	41.6	51		43	45.7	49		46	46	41.5		51	54	54	
5.2	3.4	6.6	5.1	2.1	0.7	3.6	2.13	1.2	1	3.5	###	5.6	9	9	7.87
47	53	56.9		41	36.9	42		47	42	44.4		45	45.1	48,5	
2.2	7.8	11.9	7.3	3.4	8.1	2,9	5.75	1.5	3	0.6	1.6	0.3	0.1	3.5	1.3
42	41.7	48		46	46.5	49		43	46	51		47	51.3	48.5	
3.2	3.2	2.5	2.97	1.2	1.5	3.6	2.1	2.1	1	5.6	2.8	1.8	6.3	1.5	3.2
42	52.7	48		51	50	55		47	49	52		45	42.8	51.1	
3.5	7.7	2.9	4.7	5.5	5	9.6	6.7	2	4	7.2	4.3	0.2	2.2	6.1	2.83
41	32.8	34		45	47.3	46.2		39	39	40.4		50	47.8	46.2	
4.1	12.2	11	9.1	0	2.3	1.2	1.75	6.8	6	4.6	5.7	5	2.8	1.2	3
45	41.6	42		45	50	45		46	45	42.9		45	47.8	47.1	
0.3	3.4	3.1	2.3	0	5	0.1	1.7	0.9	0	2.1	1	0.1	2.2	2.9	1.73
45	41.9	46		47	54	43		44	51	48.5		48	53	51.5	
0	3.1	0.6	1.2	2	9	2	4.33	1.1	6	3.5	###	3	8	6.5	5.83
45	43	46		40	41	41		38	39	39		45	47	46.5	
0	2.1	1.3	1.1	4.9	4.1	4.3	4.43	8	9	9.3	###	0.1	3	1.5	1.53
42	47	40		52	51	51		41	39	46		49	44.8	46.3	
3.3	2	5.5	3.6	6.5	6	6	6.17	3.6	6	0.7	3.3	4.3	0.2	1.3	1.9
41	49.8	51		46	47	48		48	47	44		47	48.3	52.3	
3.6	0.2	5.9	3.2	0.9	2	2.9	1.93	2.2	2	1.3	1.8	2	3.3	7.3	4.2
46	46.2	44		45	45.8	45		46	48	43		45	47.1	47.8	
0.6	1.2	1	0.9	0.1	0.8	0.1	0.33	1.3	3	2.2	2.1	0.5	2.1	2.8	1.8
45	45.7	46		47	48.5	46		39	42	43		48	43.5	43.6	
0.4	0.7	0.9	0.7	2	3.5	0.8	2.1	6	3	1.6	3.5	1.8	1.5	1.4	1.57
40	36	42		42	46	46		44	39	38		44	41.4	41.7	
5.1	9	3.2	5.8	3.2	0.7	0.7	1.53	0.7	6	7	4.7	1.3	3.6	3.3	2.73
			3.7				3.15				3.5				3.04
			2.6				2.06				###				1.93

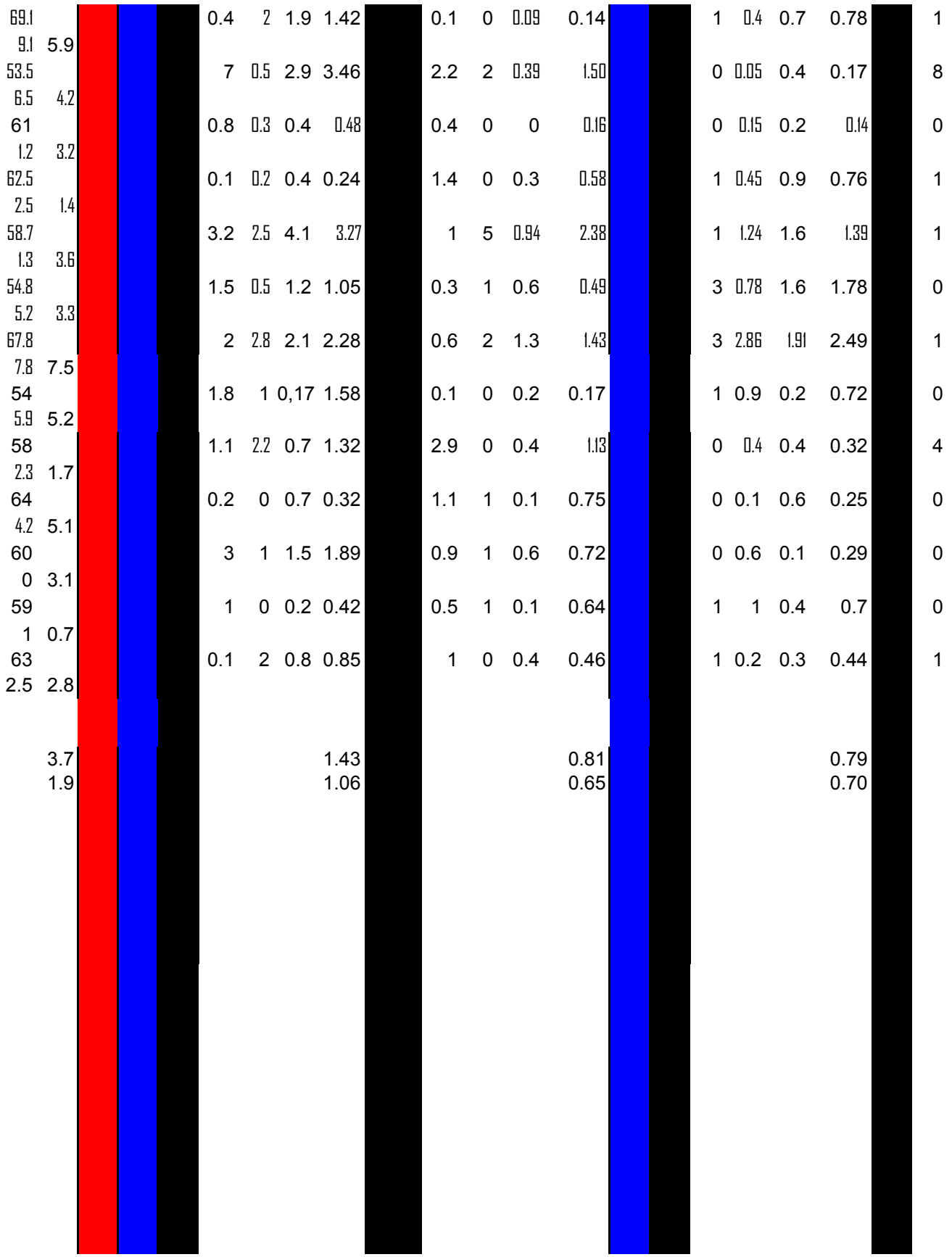


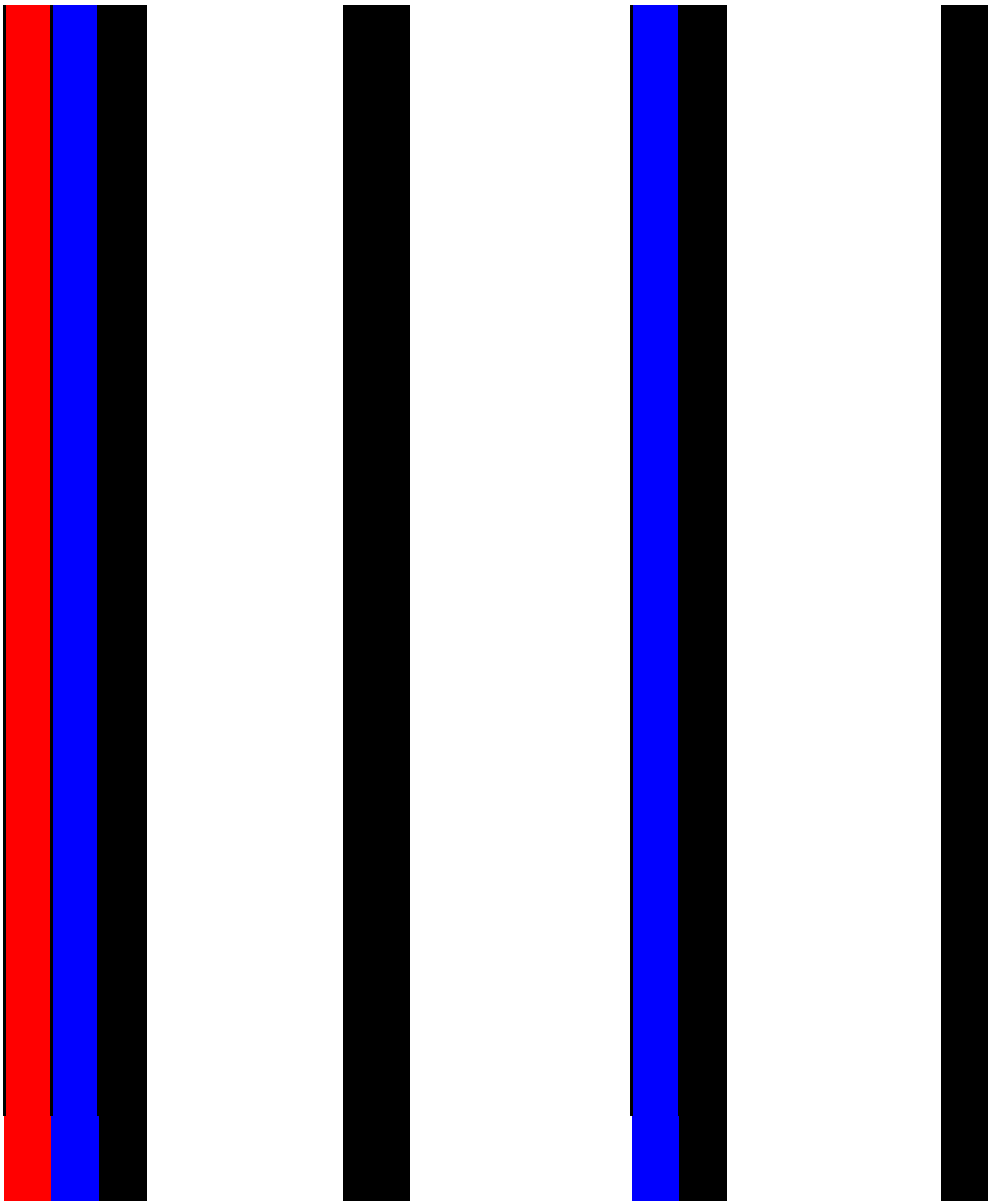
60 degrees	RIGHT KNEE JOINT	Passive Reproduction Angle				Active Reproduction Angle				LEFT KNEE JOINT	Passive Reproduction Angle				Active Reproduction Angle	
		45.7	48	55.7		58	53	48			49	57	55.5		53	61
		14.3	12	4.3	10.2	2	7	12	6.9		11	3.2	4.5	6.4	6.6	1.1
					7.1				7.1					5.2		
		60.1	63	63		66	63.6	63			53	60	58		67	67
		0.1	7.5	2.7	3.433	5.5	3.6	2.5	7		7	0	1.7	2.9	7.3	7.4
		69.3	65.4	63		68	65	63			62	53	58.4		75	70
		9.3	5.4	2.5	5.733	7.7	5	2.8	5.2		2	6.9	1.6	3.5	15	9.6
		55.7	56.5	60.9		55	58.2	56			62	51	66.7		55	62
		4.3	3.5	0.9	2.9	5	1.8	3.7	3.5		2	8.7	6.7	5.7	5.2	1.5
		58.1	59.4	56		63	61	60			55	55	55.6		63	57
		1.9	0.6	4	2.167	3.3	1	0	1.4		5	4.6	4.6	4.7	2.6	3
		56.8	58.5	61		60	62.6	63			57	61	52.7		58	58
		3.2	1.5	6	3.567	0.2	2.6	2.5	1.8		3	0.5	7.8	3.8	2.3	2.3
		59.9	63.7	65.4		65	61.5	61			64	62	56.2		63	61
		0.1	3.7	5.4	3.067	5.4	1.5	0.6	2.5		4	2	3.8	3.2	2.8	1.3
		58.4	54	52.4		58	59.9	60			52	50	58.6		62	65
		1.6	6	7.6	5.067	1.6	0.1	0.4	0.7		8	10	1.4	6.5	2.4	4.6
		62.5	52.6	57.5		54	51	56			61	60	53.9		62	62
		2.5	7.4	2.5	4.133	5.8	9	3.8	6.2		1	0.4	6.1	2.5	2.2	2.2
		63.2	66.7	64.5		56	55.8	57			63	60	66.6		65	66
		3.2	6.7	4.5	4.8	4	4.2	3	3.7		3	0.2	6.6	3.4	5.2	6.2
		58.5	58.4	62.6		62	59.8	58			62	70	62.1		57	58
		1.5	1.6	2.6	1.9	2	0.2	1.6	1.3		2	10	2.1	4.7	3.1	2.3
					4.506				3.9					4.4		
					2.338				2.4					1.4		

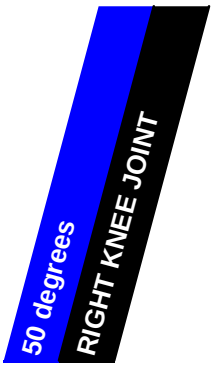
62.6	51.6	60		59	55.5	57		59	63	61.6		66	63	
2.6	8.4	0.3	3.767	1.3	4.5	3	2.9	1	2.5	1.6	1.6	5.5	3.2	
59.9	62.4	71		55	54.2	54		64	64	66		58	56	
0.1	2.4	10.6	4.367	4.7	5.8	5.8	5.4	4	4.3	6	4.8	1.7	4.3	
62	67.8	60		64	61.9	63		60	56	57		56	55	
2	7.8	0.2	3.3	3.8	1.9	2.7	2.8	0	3.6	3	2.2	3.7	4.7	
54.8	62.6	58		68	71.4	71		56	62	63		60	61	
5.2	2.6	2.4	3.4	8.2	11.4	11	10	5	2.1	2.5	3.0	0.2	1.4	
43	44.3	42		51	52.6	62.6		42	54	50.6		54	57	
17	15.7	17.7	16.8	8.6	7.4	2.6	6.2	18	5.8	9.4	11.00	6	3.4	
54.7	55.6	57		61	61.9	62		66	55	56.5		58	58	
5.3	4.4	3.1	4.267	0.9	1.9	2.2	1.7	6	4.5	3.5	4.7	2.4	2.4	
56.9	52.7	56		64	64	57		52	61	62.6		68	67	
3.1	7.3	4	4.8	3.6	4	3	3.5	8	1.4	2.6	4	7.5	7.2	
54.7	53	53		59	58	59		59	60	56		65	55	
5.3	7.3	6.8	6.467	1	1.7	0.7	1.1	1	0.3	4.3	1.87	4.7	5.1	
59.4	62.7	57		56	57	59		56	51	61		60	63	
0.6	2.7	3.5	2.267	4.5	3	1.5	3	4	8.7	0.8	4.6	0.4	2.5	
60	59.7	63		56	56.9	57		60	61	62		56	54	
0	0.3	2.6	0.967	3.7	3.1	3.1	3.3	0	0.5	1.7	0.7	4.5	6.7	
60	59.5	58		58	58.6	59		55	61	59		55	56	
9	1.5	1.7	4.067	1.8	1.4	0.8	1.3	5	1.2	1.2	2.5	5.5	3.7	
59.9	57.7	58		57	55.5	54		55	63	64		59	60	
0.1	2.3	1.8	1.4	3	4.5	5.8	4.4	5	3.2	3.7	4	0.8	0.4	
58.8	59	63		57	54	53		57	61	54		65	61	
1.2	1.3	2.5	1.667	3.2	5.8	6.7	5.2	3	1.2	6	3.3	4.7	1.2	
			4.428				3.9				3.7			
			4.017				2.5				2.5			



TDPM	20 degrees RIGHT KNEE JOINT				Average	LEFT KNEE JOINT			Average	50 degrees RIGHT KNEE JOINT				Average	LEFT KNEE JOINT
58	1.2	3	1.48	1.89		6.4	1	3.54	3.65		1	0.3	0.11	0.40	1
1.8 3.2	0.8	0.4	1.1	0.76		1.4	0	0.4	0.76					0.76	
5.2															
69	0.5	1	1.4	1.06		0	0	0	0.05		1	0.9	0.7	0.88	0
8.8 7.8															
64.2	0.7	0	0.1	0.29		1.6	1	1.2	1.36		1	0.07	0.16	0.28	0
4.2 9.7															
63.3	0.1	1	0.37	0.48		1.6	1	2.6	1.67		0	0.57	0.31	0.43	0
3.3 3.3															
57	0.8	1	0.07	0.61		0.9	0	0.1	0.40		1	0.2	1.13	0.93	1
3 2.9															
62.5	0.8	0.1	0.18	0.36		0.7	1	5.6	2.58		1	0.1	0.02	0.43	4
2.5 2.4															
70.5	0.8	0.7	0.18	0.55		0.2	1	0.2	0.34		1	0.49	0.83	0.64	1
10.5 4.9															
62.7	0.1	0.6	0.21	0.31		0.2	1	0.1	0.33		1	0.07	0.12	0.34	1
2.7 3.2															
63	2.7	1	1.53	1.75		3.7	1	0.7	1.77		2	1.35	0.07	1.27	1
3 2.5															
65.4	2.9	1	0.55	1.48		3.4	2	1.9	2.31		2	1.08	0.58	1.24	2
5.4 5.6															
60.3	2.8	1	1.24	1.67		3.1	2	1.6	2.10		0	0.24	0.26	0.23	7
0.3 1.9															
4.4				0.93					1.44					0.65	
2.4				0.61					1.11					0.36	







0.2	0.4	0.7
		0.8
0	0	0.2
1.9	1.2	1.1
0.4	1.9	0.8
0.3	0.6	0.5
0.7	0.7	1.7
0.5	0.6	0.6
1.5	0.5	0.8
1.1	0.6	1.0
0.6	0.2	1.1
0.6	0.6	2.8
		1.0
		0.7

0.1	0.4	0.3
0.7	0.6	3.0
0	0	0.1
0.1	0	0.6
1.4	1	1.1
0	0.6	0.4
2.4	1.3	1.4
0.2	0	0.2
2.1	1	2.36
0.2	1	0.35
1.2	1	0.78
0.2	0	0.1
0.1	1	0.5

0.9
0.89